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Marks, William Dennis

The finances of gas and electric light and power...

Philadelphia, Pa.?

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FINANCES

OF

Gas and Electricity Manufacturing Enterprises

BY

WM. D. MARKS

Price, $1.00, post paid.

(Second Edition)

The Finances of Gas and Electric Light and Power Enterprises.

BY

WILLIAM D. MARKS, Ph.B., C. E.,
Consulting Engineer.

Member The American Philosophical Society; Honorary Life Member of the Franklin Institute; Member of The American Institute of Electrical Engineers; Member of the American Gas Light Association, Etc., Etc.

PREFACE.

THE House of Representatives of the State of Massachusetts, February 20th, 1901, addressed the following order to the Board of Gas and Electric Light Commissioners:

" ORDERED that the Board of Gas and Electric Light Commissioners be requested to report to the House of Representatives as soon as possible cost of manufacturing and distributing electric light, and what in their opinion is a fair and reasonable price for consumers to pay for the same."

It is not necessary to quote the reply of the Board, as it is simply a model of dignified and courteous evasion, leaving the House of Representatives as innocent of any knowledge of the cost of producing electricity as it was before asking this question.

The object of this little book is to afford to those desiring to know the proper price to be charged for gas or electricity, a practical and rational method of determining the same in whatever locality may be fixed upon.

In this connection, it is proper to say that it is sometimes much more important to know *what not to do* with money to be invested than to know what to do with it.

For this reason, the first chapter has been introduced as giving an actual experience of the

type of corporation in which money should not be invested, however alluring the statements may be with which its securities are offered.

It is so true a picture of the dishonest promoters successful financial operations and of the wrecking of a great industry, that he feels that a book of to day would not be complete without it, as an example of one of the "crimes of cunning" within the law, to which President Roosevelt referred in his first message. It shows how the weakness and misfortune of consumers (compelled to buy products at a large percentage of profit on the actual investment) are combined by the promoter with the avarice and gambling instincts of investors for his own profit.

Of course, a small percentage of legitimate business as a basis is required as a vehicle in this case as well as for all illegitimate businesses.

When the bubble bursts, as it always does in the end, and the wreck is examined, we are apt to hear a great deal of "innocent investors."

However severe our condemnation of the promoters methods may be, appeals to our sympathies based on the innocence of these investors will hardly bear examination. Most of them have been very foolishly trying to make a speculative profit, and have not given careful and thorough consideration to the enterprise as an investment.

The remaining chapters are devoted to a careful analysis of the cost and prices of gas and electric light and power, and while the figures which are used, are somewhat different in each case, varying

according to locality, still the method remains the same, and will serve to elucidate many problems which have bothered engineers, electric station managers and investors.

Into every commercial enterprise three factors enter.

The first factor is the investment, its depreciation and the interest upon the investment.

The second factor is the fixed expense attached to each enterprise which must be borne regardless of the volume of business done. In a general way this may be said to be taxes, insurance, office rent and expenses, cost of supervision, hire of clerks, cost of stationery, etc., etc.

The third factor is the operating expense which increases and decreases in proportion to the volume of business done, and consists of the productive labor and the raw material used. This would include the cost of coal, of lubricating oil, waste, wages of engineers, firemen, linemen, etc., etc.

The careful consideration of these three factors in advance, and in detail, would prevent many lamentable failures, involving confiding people who have invested their money, relying on the assurance of dishonest or visionary promoters rather than on an investigation made by an honest man equipped with the trained intelligence and skill of a specialist in electricity and gas.

W. D. M.

216 The Bourse,
Philadelphia.

CONTENTS.

CHAPTER I.

(*The North American, Philadelphia, Friday, August 17, 1900.*)

The Inside Story of a Modern Aladdin, His Electric Lamp, and Gullible Philadelphians.

An Account of the Amazing Financiering of Electrical Companies in this City Which Made it Possible for One Promoter and His Associates to Garner Millions—With Nothing Else to Promote Here Aladdin Vanishes.

"OCCASIONALLY a novel is published whose theme is the doings of speculators and promoters. From the inner consciousness of the author some gigantic figure is created who engineers impossible deals, makes or breaks fabulous markets and invests the wheat pit or the stock exchange with an atmosphere of romance and horror. But one writer, however, has shown a realistic grasp of the situation. But one has treated it comprehendingly. But one has set forth in the bare language of everyday facts, unadorned with flowers of speech and unillumined with flowers of fancy, the simple history that to-day gives us our theme. That writer dear to boyhood, and doubly dear to-day, has called his plain, unvarnished chronicle, the diverting tale of "Aladdin and His Wonderful Lamp." Metaphor and change of scene have disguised the fact that this thrilling tale is not history, but prophecy. It needs to be translated into modern phraseology and the locality altered from the legendary capital of China to the brick sidewalks and asphalted streets of the Quaker City. The City Hall and the streets and the conduits under the streets remain ; but Aladdin and the wonder-working slave of the lamp—they, alas, have disappeared. Well, perhaps, not disappeared in a cloud of smoke, like the Arabian enchanters. But there is a dreadful rumor afloat that they have resigned, or are going to resign. On 'change, off 'change, in the highways and byways, the parlors of promoters, the camps of political leaders and the haunts of political heelers, nothing else is spoken of. Master and servant, these two individuals have occupied a prominent place in public attention in Philadelphia during the last few years. Beginning with the Wonderful

Lamp, they have gone on to the promotion and flotation at enormous profit – to themselves at least—of corporation after corporation (each one like the hungry snake at the Zoo swallowing the other) for lighting, heating and electrifying the city; they have absorbed electric plants, contracts, and now and then a street railway; they have been intimate with prominent politicians and influential capitalists, and now, can it be true that "the place that has known them shall know them no more?" Is it mere caprice, or has the orange been squeezed so dry that the rind may safely and contemptuously be thrown away? Have they provoked quarrels and stimulated ill feeling the better to carry out a preconceived purpose, or is it the mere desire for change and for a new outlet to their activities that causes them to fold up their tents like the Arabs and—go away? To tell the whole story would fill every column of the paper. We may give parts of it in detail from time to time. At the moment we can but outline.

"Everybody remembers the old Edison Electric Light Company and the large and small subsidiary companies which furnished electric lighting in Philadelphia. The Pennsylvania Heat, Light and Power Company was incorporated to take over these companies; its capital ran into the millions. Bonds were given for shares. The common stock was given away to the promoters and their friends, to those who subscribed to the preferred stock, to those who secured the subscriptions and to those who did the political work. At the highest premium the common and preferred, if sold, could have realized a profit of five millions of dollars; but if Aladdin and the slave of the Lamp chose to realize twenty points this side of the highest price, only three millions of dollars would have been added to bursting coffers. The earnings of the company became very large - so large that they began to attract public attention; so heavy that the taxpayer commenced to take notice; so vast was the net return that in order to diminish the apparent percentage dividend it was deemed advisable to form a new company, with a larger nominal capital, to take over the Pennsylvania Heat, Light and Power Company. It was easily done. The same promoters incorporated the Pennsylvania Manufacturing Company, and after giving to the old holders of the Heat, Light and Power Company bonds for their stock and the right to subscribe to a small proportion of the stock of the new company, they had remaining over one hundred and fifty thousand shares for themselves, for their friends, for their political supporters and generally to fix things up, so that if Bedlam ever broke loose they would be safe in the places of the mighty. Disregarding the value of the privilege which came to these promoters directly from their ownership in the shares of the parent company, they had at their disposal, as we have stated, one hundred and fifty thousand shares of stock that, with $5 paid in, sold at over $33 a share. But if this promoters' stock had been sold at an average price of only $25, it would again have given some three millions of dollars to these gentlemen as a reward for their discovery that the printing press could be operated at a small cost and produce great results. But these things grew dull. Politicians again became hungry. There were many petty jealousies. It was rumored that Aladdin had made four or five millions of dollars in a few years. It was pointed out that he had been merely an

employe of a millionaire and that all of a sudden he had appeared as a brilliant financier, printing and selling securities as fast as the public desired them. But we are ahead of our story. We hope to be able to devote more space to this modern Aladdin later on. Let us continue this branch of the subject to the end.

"The National Electric Company was formed. It took over the Southern and one or two minor concerns. The stock sold at a very large premium, but this did not dissuade those most concerned in it to name figures for it that suggested so much wealth that even the politicians were led to buy it at the very top. But it couldn't be kept up. When the break came there was some ugly talk and a good deal of bad feeling, and each one in turn was accused of opening the bag. In the course of time so high ran the feeling and so violent were the threats upon both sides that it became necessary to form another company, and so the Philadelphia Electric Company was promoted. The public still believed in the great earning capacity of the mammoth corporations. City contracts and political influence, it was believed, could pay any desired dividend on a capital of money, paper, wind or water. Privileges to subscribe for the stock sold at a premium of $6 a share, with nothing paid, and if the five hundred thousand (500,000) shares of stock which the promoters received could have been sold for only $5 it would have added another two and one-half millions of dollars to their profits. The National Electric Company was taken over and the Pennsylvania Manufacturing Company was taken over. All prior issues of stock were funded and quite liberal was the distribution of engraved bonds to the holders of these shares. It did not make much difference how many bonds were given and we don't really know whether anybody counted them or summed up the totals.

"Cursory observation would indicate that into the old companies, except the Edison, there went about six millions of dollars cash, into the Edison two millions, into the Pennsylvania Heat, Light and Power preferred three and one-half millions, into the Pennsylvania Manufacturing one and one-half millions, into the Philadelphia Electric two and one-half millions, into the National Electric three and three-quarter millions, making the apparent cash paid in all in the neighborhood of nineteen millions of dollars, against which were issued securities running up over thirty-one millions. If we add the further liability on Philadelphia Electric stock, twenty-two millions of dollars, it makes fifty-three millions—not a bad total. But take only the difference between nineteen millions and thirty-one millions, or twelve millions, and let this be added to the profits which come to the promoters—and we have about twenty-two millions cash to be accounted for.

"Is it any wonder that Mr. Aladdin finds that slow Philadelphia needs a little rest, and would prefer at this juncture to give up the onerous duties of management in order to devote time to the service of communities in which the green is very pronounced in the eyes of the inhabitants? In considering the above, we have taken no account of the profits which came through the flotation of Electric Company of America, another stock brought out by this creator of certificates, in which he probably had the right to

allot to himself thousands of shares selling at a premium running from $15 to $25 a share. If satisfied with one hundred thousand shares, here is another one and one-half millions or two millions to go into a vest pocket for petty expenses. Burglars would abandon jimmies and dark lanterns if they knew that money could be obtained so easily by those who still remain respectable members of society. Of course, Aladdin may not have gotten all this clear. He and his associates may have found it necessary, in order to stave off criticism, and to have full swing in the trade, to give to others the privilege to subscribe to these various stocks; the "right" being given at a time when the stocks were selling at a large premium, and when the temptation to sign the subscribed papers was great. One might find interesting reading in the names of those in office and out of office whose lips were sealed by the prompt application of treacle. It would make very interesting reading, but *The North American* hesitates at this juncture to publish those names, although it is in the possession of many of them.

"Now that the business is dull, what interest could Aladdin possibly have in wasting time to develop these properties? What is $50,000 a year salary, or even $100,000. The time will come again when millions can be made through the same process as before. Meanwhile Philadelphia is suffering with acute indigestion, and is not good company at the festive board spread by the servants of the lamp. What more natural than that these potent enchanters should resign from the offices which they created for themselves? Not Aladdin, but the King of China, the directors and stockholders have asked for the roc's egg the owner of the lamp and its slave must, therefore, go away in a huff. It is only envy and jealousy that suggest they have squeezed the orange dry because they vanish from Philadelphia and build magic mansions in New York and elsewhere. It is merely petty spite that could say that they will be missed only by a chosen few. It is malicious to suppose that it is rather better for the city that it need no longer be troubled with their citizenship. So far as New York is concerned, however, we may honestly doubt if either Aladdin or the Jinn will be *persona grata* to the leading financiers in that city. *Quantum sufficit!*

"R. M Q."

(*The North American, Philadelphia, August 28, 1900*)

MORE LIGHT ON THAT REMARKABLE MANIPULATION OF ELECTRIC STOCK.

Figures Which Prove That the Juggling of the Promoters Changed Annual Profits of the Separate Companies to a Deficit of $950,000 Yearly. "Pay, Pay, Pay!"

"R. M. Q., care of *The North American*.

"DEAR SIR: Your version of a 'A Modern Aladdin,' in your issue of August 17, is both interesting and correct:

"In looking over your figures I was much struck by the number of millions which have nominally been invested.

"As one familiar with electric values, and who built and operated the Edison station for nine years, I would like to give you the value of a duplication of the existing electrical equipment of Philadelphia, for light and power, regardless of the statements that have been made, or of money which may have been spent, wasted or otherwise appropriated.

"The Edison station, of Philadelphia, with a capacity of 120,000 sixteen-candle power lamps, cost $2,000,000, including $350,000 paid for patents.

"About 10,000 arc lights are used in the city, 8,000 by the city and 2,000 or more by private consumers. To build arc light stations and run their circuits underground and put up poles in the best possible manner will cost about $250 per 2,000 candle-power arc light, making the total investment required for 10 000 arc lights $2.500,000.

"Beside the 120,000 incandescent lamps attached to the Edison station, it will be safe to figure 380,000 incandescent lights receiving their current from other smaller stations in the city, making a total of 500,000 incandescent lights in the whole city.

"There is also some considerable power sold for small motive power, but this can be well included in the number of incandescent lights already estimated.

"The figures of the actual cash investments may then be written as follows:

Edison station, with additions in four years	$2,500,000
Other stations, 380,000 incandescent lights, at $15 . .	5,700,000
Arc light stations, 10,000 arc lights at $250 each . .	2,500,000
Total	$10,700,000

"Presumably the incandescent lamps are somewhat over-estimated, so that 10,000,000 is an over-estimate of the cost of duplicating all the electric apparatus and buildings used in the city of Philadelphia.

"The possible annual profit on 10,000 arc lights is between $250,000 and $300,000.

"The possible annual profit on five hundred thousand incandescent lights is between $[illegible]00,000 and $1 000,000.

"The probable deterioration of a ten million dollar plant is 9 per cent. per annum, making $900,000.

"Tabulating, we have:

Profit on arc lights	$300,000
Profit on incandescent lights	1,000,000
Total	$1,300 000
Deterioration	900 000
Net profit	$400,000

"You have mentioned $30,000,000 in securities, in the form of bonds, besides $25,000,000 in capital stock, 10 per cent. called

"The interest on $30,000,000, at 4½ per cent., is $1,350,000, which must be paid prior to any dividend, and from the earnings of these various companies. If from this we subtract the net profit of $400,000, we have left an annual deficiency of $950,000.

"Obviously there is but one source from which, in the long run, this money can come. That is the 90 per cent. of $25,000,000 stock not yet paid in, or $22,500,000, which can be collected from the holders of shares in this company, which is now said to control all of the electric lighting of Philadelphia.

"You should not attribute the doubtful honor of all of this amazing financiering to 'Aladdin.'

"In 1896 the Board of Directors of the Edison Company were most anxious to lease this property to him. Several of this board were original subscribers to the Pennsylvania Heat and Light Company, and the whole board refused to allow the officers of the Edison Company to bid on the street lighting of this city, and transmitted a formal resolution to the Directors of the Pennsylvania Heat and Light Company, assuring them of this.

"Subsequently the Edison Board sold the company to the Pennsylvania Heat, Light and Power Company, at $150 per share

"The Edison Company, at that time, was doing a good business, and paying 8 per cent. or over per annum.

"Such of the directors as were interested in the Pennsylvania Heat, Light and Power Company realized an immediate and large profit from the stock of this company, as well as 50 per cent. premium on the stock of the Edison Company.

"I leave you to judge of their venality.

"The subsequent history of the Pennsylvania Heat, Light and Power Company, which was absorbed by the Pennsylvania Manufacturing Company, and this latter, in its turn, by the Philadelphia Electric Company, need not be followed.

"The bewildering alternations of assessments, dividends, absorptions and fluctuations of stock, due to stock washing operations, are of interest only to stock gamblers, who should not ask for sympathy when they lose money.

"The finish of this legalized 'gold brick game' seems to have come rather earlier than was generally expected.

"It has been conducted with a skill and energy that must cover professional bunco-steerers with confusion, and fill them with admiration.

"I thank you for your frank and able exposure of the game.

"Respectfully,

"WILLIAM D. MARKS."

PHILADELPHIA ELECTRIC.

Year's Profits $315,000—President Says Company is Able to Begin Dividends.

"The annual report shows profits for the year ending December 31st, 1901, of $315,000. This added to a surplus of $131,000, standing over from last year, makes a surplus at the present time of $446,000.

"The President of the Philadelphia Electric Company, states in his report at the annual meeting that the affairs of the company are in a shape to warrant the commencement of dividends on the stock of the company at any early date.

"The annual report for the year ending December 31st, shows figures in detail as follows:

Gross income, all sources	$3,295,971
Operating expenses, taxes and fixed charges	2,980,791
Balance to be added to sur. account	315,179
Surplus for 15 months, ending December 31st, 1900	131,497
Total present surplus	446,677
Lamps connected December 31st, 1901, 16 c. p equiv.	675,995
Increase over last period 89,924 Increase 15.34% Increase since organization of company 35 35%.	
Advanced to subsidiary companies:	
Overhead lines	$179,917
Boilers, engines and steam apparatus	218,351
Dynamos, storage batteries and electric machinery	188,039
Underground construction	127,808
Real estate	190,487
Miscellaneous	7,855
Total	$912,460

Assets.	1901	1900
Subscription to capital stock	$19,985,400	$21,234,567
Installment No. 2	3,081	16,966
Cash	52,439	234,501
Charter and org.	35,631	35,631
Adv. general expenses	3,725	1,875
Stocks, bonds, misc Co.'s	17,113,910	17,118,567
Investment account	140,617	262,183
Accident fund	15,047	15,047
Loan account	543 000	580,000
Office furniture etc	228	228
Acc'd earn miscellaneous Co.'s	1,766,006	863,217
Installment No. 3	300,316	.....
Construction account	316 769	.....
Adv Insurance	249	.....
Material in stock	21,011	.....
Account receivable	2,232,060	.....
Total	$41,658,069	$40,362,786
Liabilities.		
Capital stock (amount called)	$5,202,350	$3,752 982
Amount subject to assessment	19,9~5,400	21,234,567
Installment No. 3	....	4 860
Land Title & Trust Co. (trustee)	15,014 142	15,013 512
Accounts payable miscellaneous Co.'s	650 000	225,366
Profits and loss	446,677	131,497
Loans	559 500	.....
Total	$41,658,069	$40,362,867

Profit and Loss Account.

Revenues.

Edison E. L. Co	$569,457
Brush E. L Co.	216,326
Northern E. L. & P. Co.	162,966
U. S E L Co.	105
Powelton E. Co.	113,387
Bala and Merion E Co.	6,343
Suburban E L Co.	70,790
Diamond E. Co.	69,541
Manufacturers' E. Co.	48,135
West End E Co	18,318
Germantown E. L Co.	32,402
Columbia E L. Co	3,298
Penna. H. L & P. Co.	54,501
Penna M. P. Co	3,407
National E Co	173,222
Phila. E. Co.	22,486
Total	$1 584.660

Less:		
Phila E. L. Co.	$992	
Kensington E Co.	4,940	
		5 932
Balance		$1,578,727
Fixed charges:		
Edison E. L. 5%	$99,643	
Phila. Elec 5%	563,436	
" " 4%	600,468	
		1,263,548
Net earnings December 31st, 1901		315,179
Cred bal " " 1900		131,497
		446 677

"The President said in his report:

"'Contracts have been made for the Christian Street station and for machinery necessary for requirements of next winter's load Additional apparatus for next year is being negotiated for, it being the purpose to instal as nearly as possible all future generating apparatus in this station. Of the assessment payable March 1st, all but $25,000 has been paid in.

"'The encouraging increase in the general business of your companies since the purchase of the shares in October, 1899, as evidenced by the amount carried to the surplus account, together with the returns for the months of January and February of the year, will show a marked increase over last year, warrants your management in early considering the commencement of the payment of conservative dividend upon the paid in capital of the company.

"'An officer stated that the earnings for January, 1902, were more than double those of January, 190 , and that the aggregate earnings for January and February, 1902, were double those of the same period last year.'"

It is of interest to learn the results of 2 years and 3 months operation, and so far as its cunningly arranged and obscure report to Dec. 31st, 1901, will permit, we will examine its (*The Phila. El. Co.'s*) condition.

There appears to be about 11,000 arc lights (not mentioned in the report) attached to its various stations. The Company claims 676,000 sixteen c. p. incandescent lights of which about 120,000 are attached to underground conductors. To duplicate all of machinery and stations, lines and lamps at

this present time would approximately require the following expenditures:

11,000 arc lights @ $250.00 each . . .	$2,750,000
120,000 inc. lights (Edison tubes) @ $15 each.	1,800,000
556,000 inc. lights (overhead wires) @ $12.50 each	6,950,000
	$11,500,000

It will suffice for our purpose to take depreciation of the whole plant at the statutory 5%, although, in fact, 10% is nearer the exact figure, when steam and electric machinery kept in the best possible repair are concerned. Whatever differences of opinions may be, all will agree that as machinery and lines are not imperishable, 5% is less than the rate of depreciation of electric plants, and 11¼% for the 2 years and 3 months, during which an accountants surplus of $446,677.00 appears, is much less than the real depreciation.

11¼ of $11,500,000	$1,293,750
Accountants surplus	446,677
Loss	$847,073

In all probability the loss is 2½ times greater. It is not until one turns to the item "capital stock amount called" $5,202,350.00, that one comprehends how this queer corporation has managed to survive under an interest charge of $1,263,548.00 annually on a bonded indebtedness of $28,273,280.00 while losing money on its operation. About $33,500,000.00 of full paid securities are issued on a plant which is worth about one-third of that amount, and which, in fact, is losing money in vast sums

every year of its operation. While this company by means of its political methods is able to hold a virtual monopoly (both public and private) of Philadelphia, lighting at its own prices, and so long as its stockholders are able to stand assessments, it will hold together with the aid of ambiguous bookkeeping.

If, however, either of these props weaken, it will fall to pieces, and we will hear the complaint of "the innocent stockholder" who did not investigate for himself or by proxy.

Of late its stock which was unloaded on the public at 3 to 4 hundred per cent. of the amount paid in has fallen to about 80% of the amount paid in and some little time will be required to arrange for another "shearing of the lambs."

Just at present the P. E. Co. is engaged in assessing its stockholders at the rate of $1.25 per share every six months, or thereabouts, and is lulling them into a fancied security by "considering the commencement of a conservative dividend (?)"

The almost incredible facts of this chapter could never have occurred under proper regulation of corporations by the State of Pennsylvania.

CHAPTER II.

Letter to a City Council Concerning the Cost of Production of Incandescent Electric Light.

RATES FOR ELECTRIC SERVICE.

"WE are indebted to Mr. W. D. Marks President, for permission to reprint the following letter, addressed to a Committee of the City Council of

"We believe that the reasoning of Mr. Marks is logical, and that his conclusions in regard to low rates for service extending over long hours per day are a direct result of approaching this difficult problem in a fearless spirit, and following the facts to a logical outcome.

"At first sight it appears unreasonable to believe that the same net profit can be obtained from operating motors or lights 10 hours per day at a rate of five cents per 1,000 watts, as will be procured in operating the same apparatus 1 hour per day at twenty-five cents per 1,000 watts, but this fact seems to be incontrovertible from the arguments submitted.

"We believe that this letter is worthy of the careful study of every individual interested in modern central station practice, and we hope will be of some value in calling attention to the benefits accruing to a central station from having as large a proportion of their load used as many hours per day as possible.

"We do not know of any better way of producing this result than by actively canvassing for motor business, as motors are used much more steadily than lights, and we feel sure that any central station can well afford to cater to this class of customers at prices very much lower than would be satisfactory for the ordinary user of lights who does not use all his lights more than one or two hours per day.

"We shall be pleased to furnish additional copies of this letter on request.

"THE ELECTRIC MFG. CO."

"October 15th, 1900.

"COMMITTEE OF CITY COUNCIL.

"*Gentlemen:*

"Referring to our verbal conference of the 10th current, relating to the prices of incandescent lighting for this city, I beg leave, after thanking you for your thoughtful courtesy, to place before you, in writing, such facts and figures as were then touched upon, for the purpose of enabling you to give them careful study before forming or expressing an opinion.

PERMANENT VALUE DUE TO PROFITABLE OPERATION

"At that conference it was agreed upon between us that no institution can be of any permanent value to any community, if, in the prosecution of its work, it does not realize a profit, or at least does not sustain a loss.

"We also courteously differed as to the proper method of fixing prices for incandescent lighting, the writer believing it to be a matter of private bargain and sale between producer and consumer, rather than one which should have prices fixed by City Council, unless along with this concession an absolute monopoly for a term of years is granted, and prices fixed after thorough and exhaustive research and adhered to with judicial fairness.

"Nor does the writer believe that the prices of incandescent lighting can be equitably fixed from a comparison and an averaging of the prices charged by electric lighting companies in adjacent cities and towns.

"When I tell you that in the great and prosperous State of New York three fourths of the electric lighting companies have never paid a dividend; when, in addition to this, I can assure you that the City of Toledo, with its marvelous increase of population, has never had in it an electric lighting company which has paid a dividend, you will begin to realize what has been most vividly borne in upon the writer that is, the fact that neither the capitalists nor the managers of most of the electric lighting companies now in operation, and which they assume to manage; have ever grasped the commercial conditions, which should control the fixation of their prices. Had they done so instead of the story of speculation, consolidation and constant loss, to which I have referred, there would have perhaps been a somewhat less general spread of incandescent lighting in all directions, but on the other hand, a greater specialized growth in directions for which it is pre eminently adapted, and the investors in these enterprises would have received a fair profit, in the form of dividends upon moneys which may now practically be regarded as lost.

MUNICIPAL ATTEMPTS AT ELECTRIC LIGHTING

"The disastrous history of municipal attempts at electric lighting also largely results from the facts to which reference has been made, and the fact 'that no man can serve two masters.' The managing political body, if it consists of men desiring votes, will not adhere closely enough to the immutable financial conditions of the undertaking to bring about pecuniary success.

"The history of attempts of municipalities is about as follows:

"By means of a general tax levy on the whole community, sufficient funds are obtained to erect an electric lighting station.

"On the assumption that no profit need be made, the prices of electric light are fixed somewhat lower than those charged by neighboring private corporations furnishing electric light, regardless of the fact that these corporations may have found themselves unable to make money or expand their business.

"The works are started and for the first year or two the bookkeeper reports a 'profit.'

"What this bookkeeper means is that the amount of money received from consumers of electric light, exceeds the amount of money paid for coal, lubricating oil, waste, lamps and the services of engineers, electricians, lineman and other attendants.

"The bookkeeper has overlooked the serious item of deterioration of plant and of interest on the money invested, so after a few years, the municipality is asked for another appropriation for 'extension of plant.' Such a thing as deterioration is never mentioned, and all question of profit is waived.

"This manœuver is repeated once or twice, and then it begins to dawn upon the hitherto benighted brain of the taxpayers using candles, oil or gas, that those using the electric lights are enjoying a luxury for which they (the taxpayers) are paying, and the works are sold at a loss, and the price of electricity rises.

"In the course of our verbal interview you emphatically rejected all ideas of a scale of charges based upon the expenditures of this company for its new works, and so I will not take the figures which might be drawn from the books, but make use of such figures as I have obtained from an experience of nearly a score of years in the operation and construction of electric lighting stations and machinery throughout the United States.

"In the case of economically but well-built incandescent electric lighting stations with overhead wiring, I have found that their cost ranges between two hundred and two hundred and fifty dollars per horse power when complete in all particulars, and ready to run. We can take an average of two hundred and twenty-five dollars as covering the cost per horse power of charter, legal services, solicitors, real estate, buildings, boilers, pumps, injectors, steam piping, engines, belting, dynamos, measuring instruments, switchboards, lines of wire, poles, insulators, converters, meters, office furniture, taxes during erection, plans, drawings, salaries of engineers and experts, labor of men erecting lines, etc.

"After what I have told you of the ill-success of capitalists and managers, having their money invested in electric lighting and pretending to manage their business, it is not at all strange that others, who perhaps have never entered an electric station, should have formed views so erroneous as to render it almost impossible for them to understand the conditions upon which electric lights can be furnished at a profit, or at least without a sure ultimate loss.

ACTUAL COST OF PRODUCING INCANDESCENT LIGHT

"I shall crave your closest possible attention, while I next take up the actual figures of the cost of product on of incandescent electric light.

"I have already told you that the average cost of electric stations per horse power is two hundred and twenty-five dollars.

"A moment's reflection will convince you that the machinery and plant used for the production of electric lights is peculiarly subject to deterioration, and you will agree with me, that placing the deterioration at ten per cent, is low rating, since the rapid progress of electrical science, any machinery not worn out will have to be replaced within ten years, in order to keep abreast of the state of the art.

"You will thus see that the sum of twenty two dollars and fifty cents must be set apart each year for each horse power installed

"In the case of this company, the fixed annual expense for office rent, taxes, salaries of clerks and managers, stationery, etc., amounts to thirty-five hundred dollars. The number of lights attached is about twelve hundred and fifty: so, if we take seventeen hundred and fifty dollars (one-half of $3,500) as the annual cost of supervision, of office expense, of reading meters, and of the thousand and one services which must be rendered our consumers in the electrical department, each lamp costs for its care, one dollar and forty cents a year.

"Theoretically, fifteen 16 candle power lamps should be operated to the horse power; practically, twelve lamps to the horse power, after the losses are deducted, is nearly the actual fact; thus we have:

For annual depreciation	$22.50 per h. p.
For annual fixed expense	16.80 per h. p.
Total	$39.30

"We have not yet taken up the question of profit on the investment, per horse power, nor the cost of the operations producing the electric current.

"Dividing $39 30 by 365 days, and again by 12 lamps, we find that each lamp attached is costing the station nine-tenths of a cent per day, while it only stands and waits in darkness to be used.

"We should, however, allow to the investors in electric lighting enterprises, a fair profit on their investment (such as we allow to others in business) as their rights.

"If we can obtain money at four per cent., on bonds or mortgages, which have no risk whatever attendant upon them, we surely ought to allow to the average business man, a profit of eight per cent., and eight per cent. of $225.00 is $18.00.

"Adding this to $39.30, and dividing the resulting $57.30 by 365 days and 12 lamps, we obtain 1.3 cents as the price per day which should be paid for lamps which stand and await the consumer's convenience without being lit, provided the consumer is wise enough and generous enough to allow his neighbor who serves him an honest and moderate profit for his services.

"Having led you to this point (as I hope, logically, and with your full concurrence), you will begin to wonder how anyone can afford to do any incandescent lighting at all

"It is right here that the saving condition allowing the existence of electric lighting enters in. The writer has found by experiments conducted on an enormous scale, using many thousand lamps attached at once, for a period of a year, that it costs but fourteen one-hundredths of a cent. (about 1-7 of a cent) to furnish the current to light a 16-c. p. lamp for one hour. This is about the same as three cents per kilowatt hour for coal, lubricating, oil, waste, lamps and services of engineers, oilers, firemen, linemen, inspectors, etc., required in manufacturing the electric current.

"To put this in another way, for one cent the current required to keep a 16-c. p. electric lamp alight for seven hours can be produced.

"It can be said, also, with commercial accuracy, that this one cent will keep two 8-c. p. lamps alight for seven hours or four 4-c. p. lamps alight for the same length of time.

"It is a remarkable fact that on the continent of Europe where incandescent electric lighting has had the combined consideration of artisan and artist, that the 8 c. p. is the standard of illumination, producing the best and most artistic effect when used in large number, but not twice as o.ten as the 16 c. p. lamp is used on this side of the Atlantic.

"Perhaps it would be simpler to ask 1 11-100 cents per lamp per day (or 4 per cent. profit on the investment required per 16 c. p. lamp) for all lamps put in, and merely reading the meter at stated intervals, to add for each lamp per hour 14 100 of a cent (about 1-7 of a cent .

"Your reply to this at once is : 'We do not use all our lamps at once. We use only half of them, or a quarter of them and consequently you are not obliged to invest $225.co in machinery, plant, etc., every time you put in twelve lamps.'

"My answer to this is : "Your statement is right, fifty-one weeks out of the fifty-two in the year, or perhaps even three hundred and sixty-four days out of the three hundred and sixty-five in the year.'

"How about Christmas Eve? – how about the week before Christmas? Are not all lights burning then?

"We cannot store electricity as we do gas, as our machinery is not light or portable. It must be there the whole year, ready to meet your uttermost needs, and if you use it but one day in the year, our money must be invested the whole year.

"Again I must ask your most careful scrutiny of the tabulated results of my figures, which are subjoined You will see that if electricity is used more than three hours, it can be sold at a profit, and still be cheaper than gas at one dollar per thousand, and if it is used for ten hours, it can be sold at the same price as illuminating gas at fifty cents per thousand, and leave a profit to the producer.

"I will say, for your information, that two hundred lamp hours of a 16-c. p. lamp furnishes the same amount of illumination as one thousand cubic feet of a 16-c. p. gas. Beginning with 1 11-100 cents we have the following scale of prices for FOUR PER CENT profit.

SELLING GAS BY METER

"You say, 'If these statements are true with regard to electricity, how is it that you can afford to sell gas by meter alone, and not require of the consumers a regular payment of so much per day per jet?'

"In our gas works we have a large holder, which will contain twenty-four times the hourly production of the retorts, but which can, if need be, be exhausted in four hours of lighting, thus enabling the works to have one-sixth of the light-producing capacity, which an electric light plant, established for the same purpose, must have.

"This city at present requires about three hundred horse power, including arc lights, but if we could store our electricity, as we do our gas, we need have but fifty horse power, with its enormous reduction in investment, provided electricity could be stored as cheaply as gas is stored in gas holders.

TABULATION

PRICE OF ONE 16-C. P. LAMP

Price for 1 hour per day . . . . . . 1.25 cents	Price per hour, 1.25 cents per 16 c. p. lamp	25 cents per K. W.
Price for 2 hours per day . . . . . . 1.39 cents	Price per hour, .69 cent per 16-c p. lamp	13.8 cents per K. W.
Price for 3 hours per day . . . . . . 1.53 cents	Price per hour, .51 cent per 16-c. p. lamp	10.2 cents per K. W.
Price for 4 hours per day . . . . . . 1 67 cents	Price per hour, .42 cent per 16-c. p. lamp	8.4 cents per K. W.
Price for 5 hours per day . . . . . . 1.81 cents	Price per hour, .36 cent per 16 c. p. lamp	7.2 cents per K. W.
Price for 6 hours per day . . . . . 1.95 cents	Price per hour, .32 cent per 16-c. p. lamp	6.4 cents per K. W.
Price for 7 hours per day . . . . . . 2.09 cents	Price per hour, .29 cent per 16-c. p. lamp . . .	5 8 cents per K. W.
Price for 8 hours per day . . . . . . 2.23 cents	Price per hour, .28 cent per 16-c. p. lamp	5.4 cents per K. W.
Price for 9 hours per day . . . . . . 2 37 cents	Price per hour .26 cent per 16 c. p. lamp	5.2 cents per K. W.
Price for 10 hours per day . . . . . . 2.51 cents	Price per hour, .25 cent per 16-c. p. lamp	5.0 cents per K. W.
Price for 11 hours per day . . . . . . 2 65 cents	Price per hour, .24 cent per 16-c. p. lamp . . .	4.8 cents per K. W.
Price for 12 hours per day . . . . . . 2.69 cents	Price per hour, .23 cent per 16-c p. lamp	4.6 cents per K. W.

COPY FOR BOOKKEEPER – METER RATES

1 hour per day, 1.25 cents per L. H., 25 o cents per K.W. hr.	3¼ hrs. per day, .48 cent per L H., 9.6 cents per K. W. hr.
1¼ hrs per day 1.03 cents per L. H, 20 6 cents per K. W. hr.	3½ hrs. per day, .45 cent per L. H, 9.0 cen's per K W. hr.
1½ hrs. per day, .88 cent per L. H, 17 6 cents per K W. hr.	3¾ hrs per day, .43 cent per L. H, 8.6 cents per K. W hr.
1¾ hrs. per day, .77 cent per L. H., 15.4 cents per K. W. hr.	4 hrs. per day, .42 cent per L. H., 8.4 cents per K. W. hr
2 hrs per day, .69 cent per L. H., 13 8 cents per K. W. hr.	4¼ hrs per day, .40 cent per L H., 8.0 cents per K. W. hr.
2¼ hrs per day, .63 cent per L. H., 12.6 cents per K. W. hr.	4½ hrs. per day, .39 cent per L. H., 7 8 cents per K. W. hr.
2½ hrs. per day .58 cent per L. H., 11.6 cents per K. W. hr.	4¾ hrs. per day, .37 cent per L. H, 7.4 cents per K. W. hr.
2¾ hrs. per day, .54 cent per L. H., 10.8 cents per K W. hr.	5 hrs. per day, .36 cent per L. H., 7.2 cents per K. W. hr.
3 hrs per day, .51 cent per L. H., 10.2 cents per K. W hr	

STORING ELECTRICITY.

"In the present state of the art. with the use of the direct current and of storage batteries, all attempts to store electricity have proved very costly, because of the limited capacity of storage batteries, and the high price charged for them. Besides this, a storage battery loses a very large percentage of the electricity stored in it.

UNPROFITABLE CONSUMERS.

"You have put the question to me: 'Why not take on unprofitable consumers, so long as the capacity of your machinery is not reached, and get what you can for them?' My reply is: 'That if an unprofitable consumer would agree to cut off his current at a day's notice, it would be good business to take him on, but such a condition cannot be extracted from any consumer. If he gets on, he wants to stay on, and if any of his neighbors hear that he is receiving special rates, they demand the same as their right, regardless of the condition, or agreeing to it, believing that the condition will never be enforced.'

FIGURES BASED ON ECONOMICAL CONDITIONS.

"In all the figures which I have given you, I have been careful to accept your statement, that 'if the parties putting in an electric light plant overestimate the probable demand for light, no attempt should be made by excessive charges to recoup losses due to bad judgment on the part of investors.'

"All of my figures are based on the assumption that just sufficient power has been installed, and sufficient investment made to meet the actual needs of this community. without any excess.

"Nearly three-fourths of the available incandescent lamp capacity has been absorbed, and the remaining one-fourth will soon be absorbed, under the new schedule, by those desiring to use illumination for three hours or more per night

THE PRICE OF ELECTRICITY HAS BEEN LOWERED.

"The statement has been made that the cost of electric light has been raised in this community. The fact of the matter is that the cost of electric lights, to those using it under conditions for which it is adapted, has been lowered

"More than one-half of the lights attached are used by flat rate consumers, paying fifty and even seventy-five cents per month.

"To every one of these I say that the careful use of these lights, for the four or five hours per night required, will result in a substantial reduction, while the company, by reason of the consumers' care for their own interests, will be able to effect a saving in coal and of wear and tear of machinery.

COMPANY DESIRES TO BE ABSOLUTELY FAIR TO ALL.

"You can count on the fingers of your hands all parties who have been affected unfavorably by the new schedule, as they are people who have put

in lights, NOT FOR THE SAKE OF ILLUMINATION, but for the sake of temporary convenience and luxury.

"This company has shown itself anxious in the case of parties who may have been unwittingly led by its former management into considerable expense for wiring, to arrange matters with them, even at considerable loss to itself, but it would be suicidal to offer to all comers rates for lighting by the Incandescent light which can result in nothing but loss.

"What man of you, leasing a piece of real estate at unprofitable rates would make it a long-term lease, or, having done so, in an incautious moment, would fix that rate for all other property which he might own?

"Very respectfully and truly yours,

"THE COMPANY,

"By its President, WM. D. MARKS."

CHAPTER III.

Commercial Analysis of Small and Unprofitable Electric Lighting and Power Enterprises.

CONSOLIDATIONS.

THE great number of consolidations of electric lighting and electric trolley railway companies that are to-day being consummated with the blind assumption that consolidation always means, if not increased income, at least decreased expenses, should lead the thoughtful technical adviser to careful analysis of each case before expressing his opinion on this subject.

Already practical experience is showing that consolidations do not always so reduce expenses as to warrant the increased capitalizations offered for investment to the public.

GREAT CITIES.

In many of our larger cities, no matter what is done in the way of extravagant first cost, no matter how heavy the fixed charges, no matter how bad the management or how great the operating expenses, the immense multitude of users of electric light and power and the teeming mass of travelers packed into trolley cars yield so large an income that the profits on the actual cost of electric stations or trolley roads are sure and generous.

There is no trouble in paying the interest and the principal of a bonded indebtedness fully equal to the cash cost of the first investment, and, in addition to this, generous dividends upon stock of perhaps far greater value than the bonds issued. The lucky manager whose lot is cast in a large city has only to cling to a fortunate position and see that the routine work is well organized and efficiently performed. He can give most of his time to "managing" his board of directors, creating as favorable an impression upon them as his knowledge of human nature permits. Interest and dividends are certain, and under such conditions that man is indeed stupid or unfortunate in his associates who does not find himself on a halcyon sea. To this favorite of fortune a suggestion of careful analysis does not appeal it would occupy much time, and would interest none of his smiling board of directors.

VILLAGES.

But to-day there exists in the smaller towns of the United States a type of manager not to be envied.

Living on a starvation salary, and perplexed by stupid advisers as to how to make money out of a community where there is little or no money to be had for any purpose ; harried by a board of directors and a body of stockholders - unable to furnish money for his most obvious and pressing needs in the way of machinery or lines, and yet grumbling because no dividends are forthcoming from a half-equipped plant—his most earnest efforts seem unavailing and

his meagre salary is always in danger of further reduction.

His board meetings, if he can get his board together, are meetings for condolence or criticism, of which he is the object. The manager will always find that in times of prosperity his board of directors say to the world, "See how well we have done," and that in times of adversity they say, "Our manager does not seem able to do as well as we expected; we must refer you to him for explanation." This unhappy type of manager often spends his days in the varied occupations of bookkeeper, business solicitor, meter expert, mechanical engineer, electrician, wireman, road boss and bill collector, going from one thing to another until, when night comes, he finds himself too weary in body and mind to think or to stand.

TAKE THE TIME FOR INVESTIGATING.

Is this wise? Is it not better for him to take the time for a careful investigation of his field of operations and a rational and practical analysis of his business?

"To make an omelet it is necessary to break eggs," but one can break eggs and produce a very poor omelet unless one thoroughly understands and follows the best methods; and it may be that our village electric manager has not clearly grasped the important points in the financial management of his plant.

To succeed in an enterprise dealing in small amounts the greatest business ability and thrift are

required, since a very little margin produces profit or loss to the company. The village manager is not like the metropolitan manager, swept along by an irresistible current of business demanding his product. Every class of customer in a village demands a careful study of its case, and as great concessions as are consistent with ultimate profit to the company.

THREE FACTORS.

There are three factors which enter into the cost of the product of every manufacturing enterprise. In the case of electric stations these products are:

(1) Lamp-hours.

(2) Horse-power hours or kilowatt-hours.

(3) Car-hours or car-miles.

The factors which make up the cost of these products are:

(1) *The Investment.* From which we obtain:

- (*a*) The annual interest on the investment per article manufactured during the year considered.
- (*b*) The annual deterioration of the plant per article manufactured during the year considered.

(2) *The Fixed Annual Charges.* These consist of taxes, insurance, rental, annual salaries, etc., covering all expenses which do not expand and contract with the volume of business done.

From these we obtain the fixed charges per article manufactured during the year considered. Bonded indebtedness is not considered for the present.

(3) *The Variable Operating Expenses.* These we obtain from the cost of material and productive labor, which varies directly with the number of articles produced, and which gives the station cost of each article, covering only the items of material and pay-roll of mechanics at the bench, motormen, conductors, etc., who should be paid by the job-hour, trip or day.

ELECTRIC TROLLEY RAILWAY.

To illustrate these points clearly the writer takes the actual case of a small trolley railway in a town of 9,000 inhabitants, and which manages to pay operating expenses, but has not paid dividends. Its description is as follows:

Track, 4½ miles long. Cars, 5 closed motor, 3 open trailer cars. Daily car-hours or car-miles run:

1st car	. 5:50 a. m. to 11:20 p. m.,	17h. 30m.,	13 round trips,	117 miles
2d car	. 6:00 a. m. to 12:30 a. m.,	18h. 30m.,	13 round trips,	117 miles
3d car	. 8:20 a. m. to 10:30 p. m.,	14h. 10m.,	10 round trips,	90 miles
Totals		50h. 10 m.		324 miles

Annual car-hours run, 18,311; annual car-miles run, 118,260; average speed per hour, 6 46 miles.

The total income of this road, with the exception of advertising and mail carrying, is derived from the operation of three cars, with the occasional use of trailers for picnics.

INCOME.

Passengers fares	$16,369.90
Advertisements	100.00
Mail carrying	150.00
	$16,619.90
Income per car-hour	90.8 cents.

The income of the road has increased about $1,200 in the last year.

We can now analyze the operations of this road, referring to the various factors of its cost and expenses.

INVESTMENT.

4½ miles of single track			$45,000
Station, car barn and machinery			20,000
8 cars, 5 equipped with motors			10,000
			$75,000
Interest (dividends 8 per cent expected). .			6,000
Deterioration—Pole lines and copper . . .			
	$9,000	10%	900
Ties	5,600	20%	1,120
Machinery . .	17,500	10%	1,750
Cars	10,000	20%	2,000
			$5,770

The cars on hand are all second-hand and of antiquated patterns. The deterioration per car-hour is 31.5 cents.

FIXED ANNUAL CHARGES.

Annual salaries	$2,694.00
Water rent and taxes	150.00
Office rent and steam heat	105.80
General office expenses.	240.00
	$3,189.80

The fixed charge per car-hour is 17.4 cents.

THE OPERATING EXPENSES.

Pay-roll—Daily, weekly and hourly		$6,285.42
Coal ($1.90 per ton) bill . .	$1,832.84	
Coal hauling	267.75	
Forge coal, stove coal . . .	27.10	$2,127.69
Material for road repairs (badly neglected)		59.25
Material for steam repairs.		212,03
Material for car repairs		594.87
		$9,279.26

The operating expenses per car-hour is 50.7 cents.

SUMMATION.

Deterioration per car hour	31.5	
Fixed charges per car-hour . . .	17.4	
		48.9 cents.
Operating expenses per car-hour . .		50.7 cents.
		99.6
Income per car-hour		90.8 cents.
Loss per car-hour		08.8 cents.

Total annual loss, 18,311 car-hours, $1,619.16.

Using accountants' methods a resume will read as follows:

Deterioration.	$5,770.00
Fixed charges.	3,189.80
Operating expenses.	9,279.26
Total	$18,239.06
Income	16,619.90
Deficit.	$1,619 16

This is the deficiency that is facing the luckless manager of this trolley road after a year of unceasing worry and work. True, if the item of deterioration is disregarded ($5.770), the manager can claim to have earned $4,150.84 above expenses, but this is only putting off the evil day of collapse from natural wear and tear.

But what of the stockholders? They are justly asking after long years of waiting, that they shall have $6,000 or more dividend among them. Seven thousand six hundred dollars more net income must be had to convert this road into a paying enterprise.

With the present system, both fixed charges and operating expenses will bear no more reduction. From past experience the manager can only hope for an increase of $1,200 next year, which reduces his deficiency to $400.

The present income of this road must be increased from $16,600 to $24,200 if steam is used.

We have noted that the three cars in use average but 6.46 miles per hour, including stops.

INCREASED SPEED.

If the statement is true, "that a trolley road prospers more the more nearly it approximates to a moving sidewalk or platform," the cars might be required to make hourly round trips; switches being put in the single track so as to enable this change, which will only slightly increase the coal bill, because of increased speed. The cars will then be run as follows:

1st car. . . 5:45 a. m. to 11:15 p. m.,	17h. 30m.,	17½ trips,	157½	miles
2d car. . . 6:05 a. m. to 12:35 a. m.,	18h. 30m.,	18½ trips,	166½	miles
3d car. . . 8:25 a. m to 10:25 p. m.,	14h.	14 trips.	126	miles
Total.	50h.		450	miles

This will require two switches at a probable cost of $250 each, but will increase the income of the road very decidedly, because increased frequency of passage and greater speed has always increased travel. The miles traveled by cars will increase by 126 miles, or about 40 per cent.

It appears safe under such conditions to assume an increase of 20 per cent. in the income—say about $3,000 per annum. There will be no increase in

wages, and hardly a perceptible increase in the coal bill, as the present engine averages only 36 horse-power, and running on friction load a good deal of the time, is obliged to waste much steam by excessive condensation.

The registered fares of the past 12 months are 337,955. There should be no difficulty in increasing them to 400,000 with the new time-table. From a loss of $1,600 we change to a profit of $1,400. To get the required net increase of income of $7,600 we still must save $4,600 elsewhere, and there is no further possible change in the direction of profit with steam power.

The concern is so small that the operating charges per car-hour are nearly equaled by the deterioration and the fixed charges. We cannot increase our business because of the size of the towns connected.

Analyzing the road under the new regime we have: Annual car-hours run, 18,250; annual car-miles run, 164,250; average speed, 9 miles.

ESTIMATED INCOME.

Last year's income	$16,619.90	
Annual increase	1,200.00	
Increase due to fast schedule	3,000.00	
	$20,819.90	
Income per car-hour		$1.14
Deterioration per car-hour	$0.315	
Fixed charges per car-hour	0.174	
Operating expenses per car-hour	0.507	$0.996
Profit per car hour		$0.144

Annual profit, 18,250 hours, $2,628.

A profit of $2,000 more is still required to pay a decent 6 per cent. dividend on the cost of this road. We have done all that experience suggests in estimating the possible future of this road, and yet find that with $1,200 annual increase we must wait three years to reach a proper dividend paying basis.

WATER POWER.

In looking over the accounts of this road we find:

Total coal expense	$2,127.69
Wages, engineer	720.00
One half deterioration machinery, $1,750	875.00
	$3,722.69

Within two and a half miles of the power house is a waterfall of 10-ft. height having a minimum of 450 horse-power during dry months. With its increased speed this railway will require an average of 1.40 × 36 horse-power, or, say, 50 horse-power. At periods when heavy grades are encountered, or when cars start simultaneously, 150 horse-power momentarily demanded. The waterfall is more than is ever required, and its surplus power can be usefully employed elsewhere.

ELECTRIC LIGHT STATION.

In the same village is a small electric light station furnishing 150 arc lights at $72 per year to the town and its citizens, and having attached about 5,000 incandescent lights. The cash value of this plant may be roughly estimated as follows:

150 arc lights at $200	$30,000
5,000 incandescent lights at $7.50	37,500
	$67,500

With coal at something over $2 per short ton in the station, there is little or no profit in these arc lights after all expenses are paid. About five tons of coal per day is required by them. The incandescent lights are all sold flat rate, and probably bring an income of $3 each per year, yielding a profit of 50 cents each.

This company complains that it makes no money, but its patrons say that its charges are outrageous, and so conscientiously burn as many lamps as they can as long as they can.

What is now happening is of no consequence, for no station can be justly and profitably run without meters. These 5,000 incandescents should average 700 lamp-hours each in the year, where meters are used, making 3,500,000 lamp-hours per year, or about 350,000 hp-hours, requiring 1,225 short tons of coal; the arc lights require 1,825 short tons of coal; the total is 3,050 short tons of coal. The coal bill is in excess of $6,000 per year. The average is 2,400 hp-hours per day with a maximum of, for arc lights, 150 horse-power; for incandescent lights, 250 horse-power; total, 400 horse-power.

THE WATER POWER.

We have found the maximum horse-power at the engines to be 450 (increased to 600 momentarily when arc lights, maximum incandescent load and trolley system are all operating at once under the most severe conditions.) For this reason a steam engine should be retained for the incandescent loads. The following estimate will cover the purchase of the power and the removal of all machinery to a

power house at the dam, and the installation of turbine and shafting:

Cost of water power and rights and existing dam		$25,000
Purchase of 500 hp machinery and building power house . .	$50,000	
Less value of electrical machinery	30,000	20,000
		$45,000
The deterioration is 10 per cent .		7,500
The fixed charges on this plant will be about 4 per cent. of its cost		3,000

The cost per horse-power is $166.67, or, for an average of 150 per 24 hours, $500 per horse power.

When an average of 150 horse-power is assumed

Cost $= \$\frac{7500}{150} + \$\frac{3000}{150} = 50 + 20 = \$70$ per year per horse power.

For 450 horse-power the cost is $23.33 per year for a horse-power.

Let us see what it has cost per horse-power in the case of the trolley company averaging 36 horse-power.

Deterioration, machinery	$1,750
Annual salaries.	2,694
Coal.	2,127
Total cost power	$6,571

Average cost of horse-power per year, $183 for operation during 18 hours out of 24.

We can now compute the returns from the consolidated water power, electric trolley and electric light companies.

INCOME.

From electric trolley company	$20,819.90	
From electric light company:		
150 arc lights at $72	10,800.00	
5,000 incandescent lights at $3.50	17,500.00	$49,119.90

INVESTMENT AND DETERIORATION.

The electric trolley company	$75,000	
Deterioration		$4,020.00
The electric light company	67,500	
Deterioration		3,750.00

FIXED CHARGES.

4 per cent of $142,500	$5,700.00

OPERATING EXPENSES.

Pay-roll	$9,000.00	
Repairs and renewals	3,000.00	
Cost of water power	12,750.00	$38,220.00
Net profit		$10,899.90

Total value:

Trolley road	$75,000.00	
Electric light company	67,500.00	
Water power and house	45,000.00	$187,500.00

Making 6 per cent. very nearly on the actual investment after every possible allowance has been made for deterioration, fixed charges and operation of works.

EXTRA POWER.

By judicious sale of extra power during daylight hours we can sell 300 horse-power at $50 per year, adding $15,000 to the company's income without interfering with the demands of the light or trolley systems.

CAPITALIZATION.

By the consolidation of these companies and the expenditure of $20,000 we can convert two losing enterprises and an unused water power into a profitable enterprise. Perhaps the matter could be arranged as follows, on the basis of an issue of $200,000 in 4 per cent. 30-year bonds:

The electric trolley company	$75,000	
The electric light company	67,500	
The water power	25,000	
Sold for cash at par	20,000	
Retained in Treasury	12,500	$200,000

The amount of stock issued will be of no consequence, as it will take the residue after paying interest on the bonds.

PASSENGER FARES.

The question frequently arises as to the proper fare to be charged to make a profit from the operation of a road.

Fares are based upon the passenger hour, or what is the same thing proportionally in most cases, the passenger mile.

The maximum travel is met by placing enough cars in regular service to meet the uttermost demands upon the road at any one time.

The practical difficulty in making a road pay arises from the fact that travel, like the tide, reaches a maximum at certain hours of the day in some seasons of the year, and that for the rest of the time the cars are only partially filled or empty.

Taking the case of the electric road above mentioned.

The total number of passenger hours generated 1,373,325

The total number of passengers riding (½ hour) 337,955

Let P = Annual passengers hour generated.
" C = Cash investment.
" (x + y) = The depreciation (x) and profit (y) on investment.
" F = The fixed annual expenses.
" O = " annual operating expenses.
" f = " price per passenger hour.
" p = " passenger hours annually sold.
" g = " cost of passenger hours generated.

$$(1)\ g = \frac{(x+y)\,C + F}{P} + \frac{O}{P}$$

$$(2)\ f = \frac{(x+y)\,C + F}{p} + \frac{O}{p}$$

$$(3)\ f = g\frac{P}{p}$$

The maximum capacity of the 3 cars is 75 passengers. Taking up the actually existing regime of the trolley line we have—assuming $(x + y) = 15\%$.

$$g = \frac{\$14,439.80 + \$9,279.26}{1,373,322} = 1.73 \text{ c. per pass. hour.}$$

We have p = 168,977 each fare riding 30 minutes.
f = $0.14 per passenger hour.
or 2 $\frac{2}{10}$ c. per passenger mile.

If we increase the speed of cars from 6.46 to 9 miles per hour, we can hope for 20% increase of fares, although the car hours are slightly diminished.

We have p = 135,182 each fare riding 20 minutes.
and f = 17.55 c. per passenger hour.
or 1.95 c. per passenger mile.

CHAPTER IV.

Commercial Electrical Measurements and Prices.

The word "commercial" indefinitely enlarges the field of electrical measurement by the introduction of the factor of the cost of production and of the price of the electrical current delivered through an electrical meter for the production of light and power at the point of purchase.

PRACTICAL FIGURES REQUIRED.

No mere theory as to the cost of the plant and of its operation is of any value. The actual figures, deduced from the cash costs of an operative plant of sufficient size to produce light and power in quantity required for a city's use, must be obtained.

OVER CAPITALIZATION.

No rational and correct basis of costs can be deduced from the capitalization of companies for which franchises, really though not openly exclusive, have been obtained through "political pull."

Too often it is the fact that parties obtaining these municipal privileges capitalize the company for a large amount over the sum really invested. The securities offered to the public are usually divided into bonds, preferred stock, and common stock. It is usual to make the bonded indebtedness about equal to the cash investment and to sell the

preferred stock with a bonus of common stock for "improvements."

The station is built and the company, with its curiously blended load of legitimate business, speculation and watered stock, is floated through the agency of political jobbery and stock washing. Of course, there is but one way to make its expanded securities valuable, and that is to take advantage of a monopoly—to charge more than a fair profit on the light and power produced. The views of the industrious and able financiers promoting these companies as to how much "water" investors will take or how much overcharging consumers will stand vary so greatly as to render it impossible for the constructing engineer to make a regular allowance for it in his estimates of prices.

PRACTICAL FIGURES.

In what follows the writer will confine himself to actual cash costs. At present prices for light and power it may be assumed with average correctness that each $20,000 of gross annual income requires about $100,000 cash investment in most of the presently existing electric light and power stations throughout the United States. The writer will take the carefully kept figures of a large incandescent light station for the basis of his work :

Cash cost of station distributing system and offices.		$2,000.000.00
Ultimate capacity of station in 16 c.p. 100-V. lamps		120,000 00
Number of 16-c.p. 110-V. lamps actually attached. .		89,359.00
Gross annual income		411,315.30
Gross annual fixed expenses	$132.677.99	
Gross annual variable expenses	88.132 78	
		$210,810.77
Gross annual profit		$200,504.53

Gross annual income per lamp attached		4.60
Gross annual fixed expenses per lamp att.	$1.46	
Gross annual variable expenses per lamp attached	98 6·10	
		$2,446
Gross annual profit per lamp attachment		$2,154
Gross annual sales of 16-c.p. lamp-hours (447-1,000 amp).		62,702,714
Income per lamp-hour sold		0,656 cent
Fixed expenses per lamp-hour sold	0 210	
Variable expenses per lamp-hour sold.	0 140	
		0 350 cent
Profit		0 306 cent

There are certain practical and approximate relations existing between the various figures given which are of service in all stations. By fixed charges are meant those charges which would go on if the fully equipped and manned station was stopped and not delivering any current for a short period. You will note that these are about 6 6-10 per cent. of the cost of the station. By variable expenses are meant coal, labor, firing and handling, oil, waste, lamp renewals, etc., all of which are consumed in proportion to the output of the station. It will be noted that these are about 21.4 per cent. of the gross annual income, and that the cost of the plant per lamp capacity is $16.67 per 16-c. p. incandescent lamp.

These figures will serve for rough estimates and comparisons of others with the existing Edison Electric Light Station of Philadelphia, which was designed, built and operated by the writer during the years of 1887 to 1896, and from which he has mostly drawn his figures, knowing them to be accurate, as the writer personally organized the business and methods of bookkeeping. This station,

after paying 53 per cent. in dividends in four years, was finally sold for $1,000,000 cash more than it cost, and therefore can be regarded as a practical success, *having paid its stockholders over 103% profit during six years of operation.*

AVERAGE HOURS OF LIGHTING.

From the preceding data we find that the average number of hours each of 89,359 attached lamps burned was 701.7 hours in a year of 365 days. It should also be stated that at the heaviest load output only a little over one-half the lamps attached were burning.

PERCENTAGE OF PROFIT.

Fifteen per cent. annual profit on the cash investment in a 120,000-light plant costing $2,000,000 should be a liberal allowance to a monopoly as covering a fair dividend and allowing for deterioration.

LONG HOURS BURNING.

The great reduction of cost due to long hours of burning is due to the fact that the variable charges only are increased. The fixed charges remain constant per year per lamp. We have practically observed that not more than one-half the lamps or power are going at once. If all attached should go on at once, a doubling of the power of the generating machinery would be required, and for this reason in the appended computations of prices it is not advisable to carry the computations further than eight hours' use of current.

Fifteen is a fair percentage of the cost of the investment which should be partially divided as

profit among the investors. We will now be able to fix a fair price for the electric current from actually realized data.

FORMULA OF COSTS.

Let C = cash cost of the plant (say, $2,000,000).

Let N = number of incandescent 16-c. p., 110-V. lamps (say, 120,000).

Let z = percentage of profit desired on the investment (say, 15%).

Let p = the price per lamp hour required to realize this (to be deduced).

Let n = annual hours burnt per lamp (to be fixed arbitrarily).

Let F = the fixed annual charges per lamp (about 6.6% of $\frac{C}{N}$) ($1.46 taken).

Let v = the variable hourly charges per lamp (about 21½% of p) (.14c.).

The annual profit on one lamp may be written as follows:

$$p\,n - [F + v\,n] = z\frac{C}{N}$$

Hence

$$p = \frac{z}{n}\frac{C}{N} + \frac{F}{n} + v.$$

Let us fix $n = 730$ hours, or 2 hours per day, we have then,

$$p = \frac{15 \times 200,000,000}{100 \times 730 \times 120,000} + \frac{730}{1.46} + 0.14 = \frac{682}{1,000} \text{ cent.}$$

Fixing $n = 1,460$ hours, or 4 hours per day, we have

$$p = 0.171 + 0.100 + 0.140 = \frac{411}{1,000} \text{ cent.}$$

Fixing $n = 2,190$ hours, or 6 hours a day, we have

$$p = 0.114 + .067 + 0.140 = \frac{321}{1,000} \text{ cent.}$$

Fixing $n = 2,920$ hours, or 8 hours per day, we have

$$p = 0.086 + 0.050 + 0.140 = 0.276 \text{ cent.}$$

It is not practically worth while to determine a selling price beyond 8 hours at which incandescent electric light can be sold, for reasons already stated.

COMPARATIVE PRICES.

As a matter of interest, 0.276 cent per lamp-hour is equivalent to $0.55 per 1,000 cubic feet for 16-candle illuminating gas—rather an astonishing result to reach with 15% profit. It also means 0 617c. per ampere-hour, or, at 110 volts, 5.61c. per kilowatt hour, or 4 18c. per horse-power hour.

WATERED STOCK.

In order to cover dividends on "watered stock" ("capitalized earnings") at any given rate, it is necessary to insert the capitalization of the company in place of the cash cost (C) of its plant in the formula above given.

MINIMUM CHARGES.

The minimum charge per lamp per year should be:

$$z\frac{C}{N} + F = \$2.50 + \$1.46 = \$3.96 \text{ to obtain } 15\% \text{ profit}$$

if discounts are made on long hours' use of current.

DISCOUNTS.

The station manager, reading these formulae, will at once grasp the fact that almost any reasonable discount from the rates for short hour (say, less than two) burning or use of current will result profitably if given to users of current beyond 2 hours per day.

MAXIMUM DEMAND.

Another question vexing the station manager's brain is maximum demand. Large office buildings, using light from 4 to 6 p. m. during the winter months and not at all during the summer, require large machinery and conductor investments, and yet, although counting as a large consumer with many lamps, are apt to prove unprofitable.

STORAGE BATTERIES.

To put in storage cells is usually more costly than to put in the generating machinery to carry their "peak loads." The question of maximum demand has been discussed repeatedly at conventions, but as the maximum demand meters used do not tell when a particular maximum demand occurs, and that is most important, they will hardly appeal to station managers as profitable in evening up the load on the station.

TWO RATES.

The fixation of two rates, the time of the higher rate of charge usually being from 5 to 11 p. m., has aroused more interest, and, where results show the station to be unevenly loaded, must be beneficial by obtaining a load at lower rates from 11 p. m. until 5 p. m. the next day. The lower rate should be about one-half the full rate for light and power, or less, as daylight loads are usually motors and lamps burning in dark rooms all day.

ELEVATOR MOTORS.

The elevator motor in business hours shows very poor returns and should have a minimum rate per horse-power per year, as perhaps should all

others. Reducing in the present example to lights at 15 to the horse-power, we have for 1 horse-power

$$\frac{C}{N} + F = \frac{15}{100} \times \frac{15 \times 2,000,000}{120,000} + 15 \times 1.46 = \$59.40.$$

There are no lamps to be renewed with motors, so this result is a little in excess. (See Chapter II.)

FIXED EXPENSES.

Assuming F at \$1.46 instead of \$1.10 theoretically right, operates to keep the manager on the safe side in all cases heretofore discussed. This prudence should control him in all cases until such time as results verify his reasoning, when he can take another step forward.

EXPERIMENT ONLY TRUSTWORTHY.

There is nothing like an experiment to destroy incorrect theories and superficial reasoning. The prices and profits obtained from the data and the formula have been bitterly denied by interested parties, yet the writer vouches for the accuracy of his numerical data and the cash payment of large earned dividends.

WATERED STOCK.

To make another trial of the formula, let us suppose the capital stock and bonds on a \$2,000,000 plant to be increased to \$10,000,000, and the task assigned to the manager of earning 10% on this amount, the station remaining as it is. For 2 hours per day average burning

$$p = \frac{10 \times 10,000,000.00}{100 \times 730 \times 120,000} + \frac{1.46}{730} + 0.14$$

or $1.140 + .200 + 0.140 = 1.48$c. per lamp hour.

This is the result of watering the capital stock to the extent of \$8,000,000. The manager must raise prices if the public will stand it. If we deem 5% sufficient profit on \$10,000,000 capital the price must be 0.910 cent for full rates instead of 0.682 cent per lamp hour on cash value. Thus we have the spectacle of promoting financiers loading down the company with fixed charges, or demands, and the managing engineer struggling to reduce the variable charges so as to pay this demand for dividends. Is it any wonder that he frequently fails to give satisfaction under such impossible conditions?

VILLAGE PLANTS.

A young mechanical engineer recently told the writer of his purchase of a 3,600-light alternating current plant in a village. This plant was practically a wreck and losing money on a flat rate. Everybody connected with it was so discouraged that no money was spent on it, and breakdowns almost every night for hours passed unnoticed. He bought the plant for \$27,000 and spent \$3,000 more on it, making a total of \$30,000. The original cost was considerably more. An overhead system was used because distances were so great.

He did what every manager should do, stayed with his plant all the time, and soon there was an end to breakdowns, as he had thoughtfully anticipated all contingencies. He introduced meters, and getting the old machinery and boilers into good economical operating shape reduced the variable expense to 1½ mills per lamp-hour. His fixed expenses were \$7,000 and his profits \$9,000 the first year.

THREE FACTORS OF COST.

The price for which anything must be sold contains three factors:

(1) The annual profit on the cost of the original investment per article made $\left(\frac{z}{n}\,\frac{C}{N}\right)$ and sold.

(2) The fixed annual expense per article made $\left(\frac{F}{n}\right)$ and sold.

(3) The variable expense per article made (v) and sold.

We have for the number of lamp hours annually sold at ¾ per 16-c. p. lamp hour, for each lamp attached.

$$n = \frac{z\,\frac{C}{N} + F}{p - v} = \frac{250 + 243}{0.75 - 0.15} = 821.66.$$

The average daily burning of the lamps on this station appears to be 2¼ hours.

ARC LIGHTING.

The case of an arc light station is somewhat different, but the same method of reasoning applies. The arc lights usually are all in use for ten hours per day, and the machinery and power capacity of the station must equal the full load.

For commercial purposes we can say that 1,000-c. p. arc light takes 55 volts and 10 amperes—550 watts. If, for example, we take a most perfectly appointed 1,000-hp. city plant, its cash cost ready to run should not exceed $250,000 ($C$) and its fixed expenses $15,000. Assuming 1,000 arc lamps the fixed annual expense per lamp are $15.00 ($F$). The variable hourly expenses per lamp (550

watts) are 1.54 cents. Assume 15% (z) as a fair profit on the capital invested and 3,650 (n) hours per year per lamp burning. Then

$$p = \frac{15}{100} \times \frac{1}{3,650} \times \frac{25,000,000.}{1.000} + \frac{1,500}{3,650} + 1.54 = 2.979 \text{ cts.}$$

we have

Profit per lamp-hour per lamp	1.028 cents.
Fixed expenses per lamp hour per lamp.	0.411 "
Variable expenses per lamp-hour per hour	1.540 "
	2,979 cents.

For ten hours per day the price should be 30 cents, or $109.50 per year. The varying cost of coal and of power as well as cost of construction of plant will affect this result; but this is a fair price for series arc lights from a first-class steam plant. Where stations are engaged in delivering power along with light, the fixation of prices per horse-power hour can be made in a similar manner.

WATER POWER.

In hydraulic power plant, where coal is eliminated and nothing is paid for the water, the variable expenses (v) almost disappear and the price becomes a question of fixed expenses per lamp-hour per lamp $\left(\frac{F}{n}\right)$ and of profit on investment per lamp-hour per lamp $\left(\frac{z}{n}\,\frac{C}{N}\right)$ This is the advantage of water power, and the only advantage. Sometimes it will be found cheaper to generate power by steam in near-by stations rather than to make a vast investment in dams, hydraulic machinery and transmission plant.

The reader can, with little effort, adapt the generalizations of the writer and determine under

all possible conditions the feasibility of a hydraulic plant. In the case of electric railways the car-hour (not the car-mile) should be the unit used.

The Susquehanna Electric Power Company proposes to dam the Susquehanna at a cost of $7,000,000, obtain 80,000 hp. by so doing, and sell this power to users within accessible distances. It will be of interest to determine the price per horse-power hour at which this company can sell power, assuming that $7,000,000 will be the total investment covering machinery and transmission plant.

We assume the annual fixed expenses at $450,000 and that ten hours in twenty-four are the average hours of use of power. The variable expenses we assume to disappear and the profit desired to be 15% on the investment. The investment is $87.50 per horse-power. The price (p) per horse-power will be for $n = 3,650$ hours; when 80,000 horse-power have been marketed and not till then

$$p = \frac{z}{n}\frac{C}{N} + \frac{F}{n} = 0.360 + 0.154 = .514 \text{ ct. per H. P. hr.},$$

or 5.14 cents per day or $18.76 per year. The Niagara Falls Power Company are said to be selling power at $20 per year per horse power. It seems to be a wisely managed enterprise and is prospering. Of course, a steam-generated horse-power cannot profitably be sold at this price.

UNIVERSAL USE OF ELECTRICITY.

If any one will stand on the roof of a high building in a great city he will see hundreds or thousands of exhaust pipes throwing out jets of

steam beside a chimney which vomits smoke or gas and ashes. Each one of these means a steam plant, which should not exist, for all the power required can be supplied at a profit and more cheaply from a great electric plant, and all the heat required can profitably be furnished for less than the cost of coal required for it in the form of hot water.

The city would be clean and the air clear and pure; no coal would come to our doors, and, being dumped into our cellars, fill our houses with dirt and ashes. Why has not this done? It can be done and has been done in the past and it would be done now, were it not for the measureless avarice of men who through corrupt methods obtain municipal franchises amounting to monopolies and then extort enormous profits from powerless citizens, covering their tracks by paying small dividends on inflated capitalizations.

ELECTRIC TRUSTS.

The vast electric trusts which are being organized throughout the United States may not, and probably will not, raise prices, nor can they reduce fixed expenses to any extent, although it is the pretext for their organization. They maintain prices in most cases, however, and they get the advantage of the immense reduction in cost of production which arises from the almost incredible increase of volume of business everywhere in this country.

The promoters always provide for the division of the amazing profits resulting by issuing millions of stock and selling it to "innocent parties." This is nothing more than a legalized "gold-brick game."

If these "innocent parties" would be careful to see that the capitalization of a company did not exceed the cost of its plant before purchasing a stop would be put to "get rich quick schemes" and prices would fall with healthy competition.

SUGGESTION AS TO CORPORATIONS.

The writer may be pardoned, he trusts, for saying that a corporation capitalized only to the extent of its cash investment, restricted to a fair dividend of about 8 per cent. and a reserve of 7 per cent. for large renewals and repairs, is a beneficent institution. Its management should be honest and able and its prices to the public reduced as larger business brings down the cost of production—the dividends remaining constant. Such an ideal, however, seems too Utopian for realization to-day. Municipal plants in the hands of citizens of public spirit and probity are our only hope.

"INNOCENT PARTIES?"

The company which has served our purpose as a basis for computation was steadily engaged in earning big dividends and reducing prices to consumers and the city, when its board of directors for business reasons (several of them were subscribers to the purchasing company) sold it to another company, and since then it has twice been sold again.

Now its modest cost of two or three millions is represented by about 10 or 15 millions in bonds and preferred and common stock, and none of the three purchasing companies (two have been swallowed by

successors) has ever made a frank showing of earnings. When competition does get a foothold "innocent parties" will have a lot of valueless stock and deserve no sympathy. Of course, no manager can earn a dividend on a tenfold watered stock honestly. All of these commercial phases of electric lighting may appear of little value to the reader interested only in scientific work but to the *Station Manager*, for whom this paper is written he trusts it will be of interest and value, as covering the ground upon which he is placed, and perhaps clearing up the situation enough to tell him whether he can hope to earn dividends at fair rates for light and power.

SELLING UNIT.

With the question of cost of current production solved, the next is, how shall we sell it? By contract or flat rate? By the lamp-hour? By the horse-power-hour? By the ampere-hour? Or by the watt-hour? There are cases, as of constant motive power, or of series arc lights, for which measurements need be made only occasionally, as the hours of use are fixed, and in these a contract is commercially the best arrangement. The reader, doubtless, has noticed that in what precedes, the writer has used the lamp-hour, although the steady trend of recent practice is to sell light and power by the kilowatt-hour. There is reason for this, which will appear when incandescent lighting is discussed.

Wherever the number of lamps lighted or the length of time they burn is uncertain, a meter is required. This is equally true of motive power. What gives the most reliable result as between

company and consumer, watt measurements or ampere measurements? With varying potential and current, as in trolley car motors, wattmeters are required and should give the more correct results; with constant potential and varying current, direct or alternating amperemeters are more certain and correct. This is particularly true in incandescent lighting, for which more than three-quarters of all the meters made are used.

CANDLE-POWER OF INCANDESCENT LAMPS.

As a preliminary to a comparison of watt with ampere measurements of current for incandescent lighting, it is proper to call attention to the fact that the candle-power of an incandescent lamp does not vary directly proportionally to either the watts or the amperes forced through its carbon filament. No known law is established enabling one to connect together all the factors entering into the operation of an incandescent lamp. In this matter we must turn to experiment as our guide.

The table which follows is based upon many thousand experiments covering years of work, and with its aid we will compare the results of measurements in watts and in amperes as an index of the illumination furnished. The consumer cares only for the resultant light. The station manager desires, as a matter of good business policy, to give precisely the illumination sold. It is essential to the success of the station that the meter shall record, if not the light in candle power, that factor of the electric current which is most nearly proportional to it on an average.

Let E_n be normal Voltage of lamp.
" P_n " " Candle-power.
" W_n " " Watts per Candle power.

From the following tabulated experimental results we can establish the following questions. Let V be the variation in volts from the normal E. For any lamp we have approximately:

$P = P_n \left(1 + \frac{6V}{100}\right)$ For instance, if we assume

$P_n = 16$ and $V = +3$, we have

$$P = 16 \left(1 + \frac{6 \times 3}{100}\right) = 19 \text{ candles approximately.}$$

If we assume $V = -2$ we have

$$P = 16 \left(1 - \frac{6 \times 2}{100}\right) = 14 \text{ candles approximately.}$$

Inspection of the following table shows that the candle-power of incandescent lamps varies directly with the variation in the voltage from the normal, and that roughly we can say, "a volt a candle," within allowable limits of variation in ordinary good practice with 16-cp lamps normal near 100 volts.

We can also say that $V = E - E_n$,

E being the electromotive force actually at the lamp, our equation then becomes:

$$P = P_n \left[1 + \frac{6(E - E_n)}{100}\right] = P_n - \frac{6 P_n E_n}{100} + \frac{6}{100} P_n E$$

$$P = P_n \left(1 - \frac{6 E_n}{100} + \frac{6}{100} E\right) = \frac{6}{100} P_n A R - \text{constant}$$

in which E is the independent variable; P the dependent variable, and the rest are constants. We have thus found a commercially handy relation, showing the candle-power of a lamp, P, to be a

function of the voltage at the lamp, E, or since the resistance R is nearly constant, of A (amperes). The vast sums of money invested in incandescent electric lighting render the smallest details of it worthy of careful experimental investigation.

The following table of experimental data and its application to a 100-volt, 16-cp incandescent lamp will form the basis of our investigation of the accuracy of ampere measurement or watt measurement for incandescent electric light :

Experimental Value.			Application to 100 Volt. 16 c. p. Lamp.			
Voltage % Normal.	C. P. % Normal.	Watts Per Candle.	Candle Power from Data.	One Lamp Watts from Data.	Comp. of Amps. Carbons Const. R.	Comp. of Amps. from obs. Watts.
94	69	3.92	11.04	43.28	0.466	0.460
95	74	3.76	11.84	44.52	.472	.469
96	79	3.6	12.64	45.50	.477	.474
97	84	3.45	13.44	45.68	.481	.478
98	89	3.34	14.24	47.56	.486	.485
99	94	3.22	15.04	48.43	491	.489
100	100	3.1	16.00	49.6	.496	.496
101	106	2.99	16.96	50.71	.501	.502
102	112	2.9	17.92	51.97	.506	.509
103	118	2.8	18.88	52.86	.511	.513
104	124	2.7	19.84	54.57	.516	.515
105	131	2.62	20.96	54.91	.521	.523
106	138	2.54	22.08	56.08	.526	.529

CONSUMERS' BILLS.

To further reduce to commercial practice we will take up the meter bills of a consumer using 20 lamps—100-volt, 16-cp—for two hours each day for one year, and from the above tabulated results

show how ampere measurement and watt measurement compare with the actual light delivered to him.

The assumption is made that the voltage can be kept constant with an allowed variation of 3 volts either way, and that the average is 100 volts.

This is within limits which should exist in all stations.

At 97 volts a 16-cp lamp 100 nor. gives 13.44 candles.

His just bill.	12264	Sixteen c p l hours at $\frac{744}{1000}$c.	\$ 91.24
" Watt "	$666\frac{928}{100}$	K. W. hours at 15c.	100.04
" Amp. "	$6978\frac{8}{10}$	Amp. hours at 1½c.	104.68

At 100 volts a 16-cp lamp 100 nor. gives 16 candles.

His just bill.	14600	sixteen c p l hours at $\frac{744}{1000}$c.	\$108.62
" Watt "	$724\frac{160}{1000}$	K. W. hours at 15c.	108.62
" Amp. "	$7241\frac{6}{10}$	Amp. hours at 1½c.	108.62

At 103 volts a 16-cp lamp 100 nor. gives $18\frac{88}{100}$ candles.

His just bill.	17248	sixteen c p l hours at $\frac{744}{1000}$c.	\$128.31
" Watt "	$771\frac{756}{1000}$	K. W. hours at 15c.	115.76
" Amp. "	$7489\frac{8}{10}$	Amp. hours at 1½c.	112.35

What the consumer has contracted for and the company agreed to deliver is twenty 16-cp lamp held at that illumination and the just bill for it is \$108.62. He cannot honestly be held for anything else or for variations in voltage and light.

The average of the watt measurements is \$108.14.

The average of the ampere measurements is \$108.55.

The assumption is that the extreme allowable variation either way from normal voltage is 3%, and that the normal voltage is very closely aver-

aged. The error of the watt meter is 48 cents and of the ampere meter 7 cents, assuming both to measure with perfect accuracy.

The average 16-cp lamp hours delivered is 14,702 ($109.38). Where, as in this case, a contract has been made for 14,600 ($108.62), the ampere measurement is more nearly correct than the watt measurements. The average candle-power of the lamps is 16 11-100.

The wise, skilful and honest station manager who will be careful to keep his district voltage within a 3% variation from normal will find that ampere measurements are more correct and more just and profitable to the station than watt measurements for light, and he will also find that there is no advertisement equal to a satisfied consumer, and that no comforts are greater than small lamp renewals and a full treasury.

Should anyone be so unfortunate as to have wide variations in voltage, ampere measurements do not vary so widely from the contract average of light, and therefore will not create dissatisfaction among consumers by unexpectedly great variations in bills from the estimated contract price.

The theorist unfamiliar with practical station running might at first sight say that watt measurements approximate more closely to just records than ampere measurements, but on second thought he will see that owing to more rapid variations in the watts the average is not so correct, and all stations must be run on averages.

We have in the preceding example:

The contract price	$108.62
Actual lamp hours (14,702)	109.38
Average ampere hours	108.55
" watt "	108.14

Both show an actual loss to the station of light delivered but not metered to the consumer, and it amounts to a great deal of money. The difference between ampere measurement averages and watt measurement averages is 48 cents in $108.55, or 44 2-10 cents saved per $100 gross income. For a gross income of $500,000 this difference amounts to $2,210 in a year. There is a further measurement loss in lamp hours of nearly the same amount, but we have as yet no meter capable of registering it.

VARYING VOLTAGE.

There also remains, in badly managed stations, the two cases of voltage habitually carried low or high.

In the first case, an enormous injury is done to electric lighting, and no saving in lamp-life can compensate for the loss of business to the electric company which will immediately result. In the second case, voltage is sometimes purposely put up two or three volts while burning out old and blackened lamps and replacing them with new ones of the higher voltage. In this case the lower records of the amperemeter as compared with the wattmeter compensate for the loss of brilliancy in the old lamps and give a more correct result for the new lamps of higher voltage.

INCANDESCENT CURRENT MOST CORRECTLY MEASURED IN AMPERES.

Whatever the voltage may be, and whether the current be direct or alternating, amperemeters average more correct results than wattmeters in the measurement of incandescent electric light, and should for this reason be used for it. The further mathematical reason for this is that (*P*) the candle-power of a lamp is a function of the voltage (*E*), minus a constant, and since the resistance of the filament of a lamp (*R*) is constant within the usual limits of incandescence, (*P*) the candle-power is also a function of the current (*A*) passing, and not of (*EA*) the watts used.

WATT MEASUREMENT OF INCANDESCENT LIGHT CAUSES A LOSS.

To the station manager this will be obvious. *To use a wattmeter in a well-regulated incandescent station is to lose a great deal of honestly earned money for your company;* maybe a good portion of your own salary, which, it is expected, you will save many times over because of your special skill in science and conscientious vigilance in making and saving money as manager.

DEDUCTIONS.

The conclusions reached up to this point are:

The length of time of use of the electric current is the most important factor in fixing its price.

Watts should be the basis of measurement of power with varying potential.

Amperes should be the basis of measurement of incandescent light with approximately constant potential.

METERS.

We come next to the meters—there are hundreds of them; some based on watts, some on amperes, but of these meters less than a dozen types have been practically used on a large scale.

CHEMICAL METERS.

The Edison chemical amperemeter, while giving correct results, has been prohibited by law in many countries and is constantly suspected by consumers, and for that reason seems after many years of good service to be going out of use, being replaced by various mechanical meters. On direct constant potential currents it has not been found inferior to the mechanical wattmeter.

WATT METERS.

Speaking of loss in unrecorded current, the expert of the largest Edison company in the West says, after an experience with thousands of meters: "With our chemical meters this loss was averaging about 18 per cent., and now with one-half of our output measured by wattmeters it is but 2 per cent. better, so that it would still amount to 14 per cent. if wattmeters should be adopted entirely. This is undoubtedly due to the fact that after being in use for some time the meters become much slower on light loads than on one-half load." (*This means 14 per cent. of the gross station income.*)

"It is not the intention of this paper to at all decry the wattmeter; yet it is true that it has not come fully up to our expectations as an improvement over the old chemical meter. In point of expense its first cost is more, and its operating expense fully as large. In point of accuracy it has so far proved little better, though it seems to have possibilities of better results *with frequent and careful inspection*."

"In point of general acceptability to customers, however, this meter is far in advance of the chemical meter."

FRICTION.

The essence of this able expert's paper is that friction in the recording train of gears and at the commutator brushes and on the supporting jewel all combine to slow the meter, and that in a little time this friction grows so that it is greater than the power of the motor for one or two lamps, and this, too, after showing marvelously accurate results during a short preliminary test in the laboratory.

Placing himself on the consumer's side, he further says:

DEMAGNETIZATION.

"The liability of the meter to become fast owing to the demagnetization of the drag magnets by a short circuit must be carefully looked after or the consumer may have just cause for complaint."

In one case a 450 ampere 110 volt meter was found 47 per cent. fast owing to a heavy short circuit on the line, and frequently meters are found from 20 to 30 per cent. fast from this cause.

JEWELS.

"As to the large number of defective jewels which were found, it seems impossible to get a jewel that will not crack or wear under the weight of a meter disc and armature."

These words from an absolutely impartial expert are quoted in preference to giving the writer's own opinion, which some might think biased by his own labors in the field of electric measurement.

CONDITIONS TO BE FILLED BY A GOOD METER.

We can now state the conditions which a commercial meter must fulfil before the mechanical meter can be perfected.

(1) It must be a strong machine capable of withstanding ordinary shocks of handling.

(2) It must work well when a little out of order, not requiring exquisite adjustment to do its work.

(3) Its record must not be affected by friction.

(4) Its record must not be affected by varying permanent magnets used as a brake or drag.

(5) It should show the passing load all the time.

(6) It should record its load in a straight row of figures not on dials.

(7) It should be able to record a commercially light load of about 1 per cent. of its rated capacity unless this falls below say ¼ ampere or 25 watts. It is not commercially worth while to go below these small amounts.

(8) Its motive current should cost very little.

(9) It should not require lubrication or be made

incorrect by a little dirt or dust, requiring only ordinary care and cleanliness.

(10) It should withstand short circuits without derangement of its calibration.

(11) It should be calibrated ready for erection and not require a subsequent recalibration after erection.

(12) *Once right it should always be right; i. e.*, the principles upon which a mechanical meter is designed must be such that there is no reason, if the maker's work is done properly, why the meter should not always register correctly until worn out.

TROUBLES WITH WATTMETERS.

One of the difficulties with all wattmeters results from the feeble force with which two solenoids without iron cores tend to place themselves in the same plane with coincident axes, and their weak control of attachments to them. Theoretically, at least, wattmeters should be used for power measurement with varying potentials and inductive loads. With the existing wattmeters and the feeble forces moving them, the influence of variation of friction in recording trains, commutator brushes and jewels frequently causes heavy losses, and again the variation of strenghth of the drag magnets causes the meter to wildly run away.

VAST LOSSES INCURRED.

The 14 per cent. loss which the meter expert of the Chicago Edison Company regretfully deplored was probably 14 per cent. of a million—$140,000—lost that year, about 7 per cent. divi-

dend on $2,000,000 of their investment. It is worth looking after and getting. There are Klondikes outside of Alaska !

ADVANTAGES OF AMPERE MEASUREMENT.

Aside from the fact that amperes measure incandescent illumination more correctly under commercial conditions than watts, an amperemeter has a very strong control of its measuring needle, which can be made just as strong and certain as desired, and the lag entirely eliminated by carrying a shunt circuit around a soft iron needle, so as to supersaturate it with electromagnetism. This the writer has done and experimentally proved. For this practical reason, if no other, direct and alternating constant potential circuits should have amperemeters attached for all non-inductive loads, and perhaps for some inductive loads, with a power factor. If the recording train is driven by means of an armature or disc, any variation in the friction of the meter will show itself in the speed of rotation of this disc or armature and the meter be in error. At light loads the friction seems to be most vicious in its effects.

THE PERFECT METER.

A clock train controlled by a pendulum or balance-wheel seems to be the only mechanism whose record of time is independent of variations of friction, and for this reason the only method of making electric meters independent of variations in friction in their records. This pendulum or balance-wheel movement the writer has utilized in his work, making it electrically-driven and self-starting.

The final meter upon which all will agree will be made under the 12 conditions placed, and will drive out all others in which the principles involved are incorrect, or which having makeshifts in them carry with them an apology and warning to look out for them to the purchaser and user.

The realization in a practical form of the perfect pendulum meter is a matter of patience and ingenuity and rich should be the reward to its creator. It is not an impossible task, and present forms of motor meters on the market will vanish before it, as the Edison chemical meter is now doing before them.

CHAPTER V.

Methods of Establishing Prices for Gas and Electricity.

GAS.

THE report of the Gas and Electric Light Commissioners of Massachusetts for 1901 while not full enough in the department of electricity to give all data required for the fixation of prices from practical existing examples, is still sufficiently complete for this purpose where gas works are concerned.

Where the Commissioners appointed are men of integrity, and properly equipped with knowledge of their subject, it is impossible to overestimate the value of such a body to the community at large.

The securities of the Gas and Electric Companies in the State of Massachusetts have become under their watchful care thoroughly reliable investments.

While of course the Board cannot prevent bad internal management of the manufacturing processes or in any way guarantee dividends and interest to these Companies, still this Gas and Electric Light Commission has prevented the issuance of bonds or of stock beyond the actual cash value of the various companies' investments and by their watchful care as to prices both for gas and

electricity have allowed such fair and reasonable charges for services as enables the companies to pay to the investors tolerably sure and fair dividends and sometimes exceedingly liberal ones, where ability shown in the manufacturing department has enabled the company to reach unusual economies.

A careful study of the annual report of the Board of Gas and Electric Light Commissioners of the State of Massachusetts is perhaps the most valuable investigation that can be taken up by any person interested in gas or electricity.

It should be particularly noted that the prices for both gas and electricity throughout that State will *average* higher than in almost any other State in the United States.

The reason of this is that the Commission has ever recognized the rights of investors in gas and electricity to a fair profit and has carefully guarded against the reckless and ignorant competition permitted and fostered in most of the other States of the United States.

Indeed, every State in the United States, if it had a properly appointed Board to control their gas and electric light industries would do much to protect the interests of the companies organized to furnish gas and electricity and would render their securities a valuable, and it might almost be said, a standard investment.

Referring now at random to the gas companies whose balance sheets appear in the report of the Commissioners for 1901.

The Worcester Gas Light Co., serving a population of 118,000 people with gas at $1.00 per thousand, has a cash investment of $808,221, and a capital of $600,000. During the past year it has made two dividends aggregating 18% on the capital stock of $600,000. The investment per thousand sold is $2.89. The manufacturing and distributing cost of their gas is 50½ cents and the investment cost, covering 10% profit and 5% depreciation, is $43\frac{3}{10}$ cents, making about 94 cents.

It would appear as though the net profit after allowing the 5% depreciation in the total assets is about 8%.

This Company seems to have put its depreciation somewhat too low in its balance sheet.

By reason of its good management it has obtained an unusually large consumption per capita of population and a low manufacturing and distributing cost.

In the tabulation which follows based upon formulae which will be more carefully explained, a sliding scale of prices for consumers, has been worked out ranging from $1.55 per thousand to the individual who purchases 6,000 a year or less, to 98 cents per thousand to the individual who burns 96,000 cubic feet per year. This sliding scale is worked out under the assumption that the fixed expenses of the business should be divided equally amongst the meters and not added to the cost per thousand of the gas.

The advantage of this will be seen from the fact that it enables the encouragement of the larger

manufacturing consumers to use the gas close to actual cost of production and at a rate lower than the average required which in this case is \$1.06 to all purchasers at a uniform price for gas.

The Attleboro Gas Co., serving a population of 11,335, selling gas at \$1.52 appears to have made an average profit of 6%. The manufacturing and distributing cost is 72½ cents and its investment cost is 70½ cents per thousand.

For this, too, a sliding scale has been shown and the average price of \$1.70 computed in order to yield to the company 5% depreciation and 10% profit on its actual investment of \$95,528.

Its capital is \$46,400 and is relatively so small as to have enabled a 12% dividend during the past year.

The Marblehead Gas Company, which has not paid any dividends, nor even paid its manufacturing expenses in a town of 7,582 inhabitants, with the price of gas at \$2.04 a thousand, is an exceedingly interesting study. With a net investment of \$33,622, it has sold 2,473,000 cubic feet of gas during one year. Its manufacturing cost with distribution is \$1.72½ per thousand and its investment cost is \$2.04 per thousand. The average price necessary under these conditions, to yield 5% depreciation and 10% profit on the net cash investment, is \$4.36. This Company has incurred a loss of 7% while selling gas at \$2.04 per thousand.

The manufacturing and distributing cost appears abnormally high and the fixed expenses of \$1,461.11 appear abnormally low.

With this much in the way of general criticism, we will take up the mathematical treatment of the balance sheets of these three gas companies taken at random from the Massachusetts Commissioners' report.

The shorthand reasoning of Algebra will best serve us:

Let $C =$ Cash investment in plant and working capital.
" $N =$ Annual sales of gas in (M) thousands.
" $F =$ Fixed expenses of gas plant.
" $K =$ Number of consumers or meters.
" $x =$ Percentage of profit on investment.
" $y =$ " " depreciation on investment.
" $v =$ Manufacturing and distributing cost of gas per M.
" $p =$ Average selling price of gas per M.
" $n =$ Annual sales to any given consumer in Ms.

$\frac{C}{N} =$ Cash investment per annual M.

$\frac{F}{K} =$ Annual fixed expense per meter or consumer.

$v =$ Total mfg. and dist. expense divided by N.

We can then write the following equations:

$np =$ Annual bill of consumer.

$(x+y)\frac{C}{N}n =$ Investment's, profit and depreciation for one year for any given consumer.

$\frac{F}{K} =$ Fixed annual expense per meter.

$nv =$ Mfg. and dist. cost for one year.

$$np = (x+y)\frac{C}{N}n + \frac{F}{K} + nv$$

$$(1)\quad p = (x+y)\frac{C}{N} + \frac{F}{Kn} + v$$

$$(2)\quad x = \frac{N}{C}\left(p - \frac{F}{Kn} - v\right) - y$$

Formula (1) makes each consumer pay an equal share of the fixed expenses of office expenses, salaries, insurance taxes, etc.

If in it we make K = unity and $n=N$ we obtain the average price of gas for whole output sold. Equation (2) shows the causes of increase or decrease of profits in a very concise form.

PRICES OF ELECTRIC POWER

In considering the cost and price of electric power we must bear the following points in mind:

Electricity cannot be profitably stored in quantity in the present state of the art.

Electric storage batteries do not pay when compared with the cost of generating machinery. The boilers, engines and generators installed must equal or exceed in capacity the uttermost demand which the lights or motors attached can ever make upon them. Whenever a consumer is attached, requiring power for light or motors, the generator capacity installed in the electric station must equal his maximum possible demands.

Sometimes the power required of a station never exceeds ½ or ⅔ the total power of its attached load, but to allow for breakdowns it is never safe to run a station on a narrow margin.

A consumer should pay the profit on and the depreciation of the generating investment installed to meet his maximum demand, and also his proportion of the fixed expense of the company besides the cost of his power.

Name of Corporation with Population.	N = Annual Sales — M.	C = Cash Invested Assets.)	v = Mfg. Cost of Gas with Distribution per M.	F = Fixed Expenses.	K = No. of Meters. (Consumers)?	n = Annual Sales to a Consumer in M.	x = % Profit.	y = % Depreciation	p = Selling Price.	$p = x\frac{C}{N} + y\frac{C}{N} + \frac{F}{Kn} + v$
Worcester Gas Light Co. 118 421.	279,313	$808,221 68	50½c.	$36,089.41	9856	6	10	5	$1 55	$\frac{C}{N}$ $2.89 Inv. per M. 15% = 43.3.
Capital $600,000 00						12	.	.	1 25	Total mfg. and dist. cost $141,196.31.
Dividends 12%						24	.	.	1 09	
" 6%						48	.	.	1.02	
						96	.	.	.98	$\frac{F}{K}$ = $3.66 annual meter rental?
	Average price for 10% profit 1 meter.					279,313	.	.	1 06	
$np = (x+y)\frac{C}{N}n + vn + \frac{F}{K}$ Hence $x = \frac{N}{C}\left(p - \frac{F}{Kn} - v\right) - y = \frac{1}{289}(100-13-50.5) - \frac{5}{100}$ = 8% average profit realized at $1.										
Attleboro Gas Light Company. Corporation . . . 11,335.	20,043	$95.528 31	75½c.	$4,793 96	712	6	10	5	$2 58	Total mfg and dist. cost $15,131.08.
Capital $46,400.00						12	.	.	2 02	$\frac{C}{N}$ = $4.77. $\frac{F}{K}$ = $6.75
Dividend 12%						24	.	.	1.74	
						48	.	.	1 60	
						96	.	.	1.53	
	Average price for 10% profit, 1 meter.					20,043			1.70	15% = $(x+y)$ = 70½c.
$\frac{1}{477}(152-24-75.5) - \frac{5}{100}$ = 6% average profit realized at $1.52.										
Marblehead Gas and Electric Light Co. . . . . . . 7,582.	2,473	$33,622.26	$1.72½	$1.461.11	284	6	10	5	$4 61	Total mfg. and dist. cost $4,268.37
Capital Stock . . $20,000 00						12	.	.	4 19	$\frac{C}{N}$ = $13 59. $\frac{F}{K}$ = $5 14
Bonds 10 000.00						24	.	.	3.97	
Dividend . . . . . . None						48	.	.	3 87	
						96	.	.	3 81	
	Average price for 10% profit, 1 meter.					2,473			4 36	15% = $(x+y)$ = $2.04.
$\frac{1}{1359}(204-59-172) - \frac{5}{100}$ = 7% average loss incurred at $2.04.										

Let C = The cash investment of the company.
" N = The total installed H. P. of the company.
" I = " " " " " " a consumer.
" n = The indicated H. P. hours used by consumer.
" p = " price of a " " " " " "
" v = " cost " " " " " " " "
" x = " percentage of profit expected on investment.
" y = " " " depreciation expected on investment.
" $\frac{C}{N}$ = Cash investment per H. P. installed.
F = Annual fixed expenses of the company.

Writing the equation for one year we have :

$$p\,n = (x+y)\frac{C}{N}I + \frac{F}{N}I + n\,v$$

$$(3)\quad p = \Big[(x+y)\,C + F\Big]\frac{I}{N\,n} + v$$

$$(4)\quad x = (p - v)\frac{N\,n}{I\,C} - \frac{F}{C} - y$$

The report of the Massachusetts Commissioners does not furnish data with which to fix the value of v or the cost of a H. P. hour measured to a consumer.

It says :

" From data in the latest annual returns it appears that the cost at the station or cost of manufacturing raised during the year ending June 30, 1900, in different companies from less than 2 to more than 7 cents per kilowatt hour.

" The cost of distribution including management from 1 to nearly 6 cents, while the dividend cost varied yet more widely."

This statement will hardly enlighten the seeker for quantitative results.

The writer knows of an incandescent station having 90,000 lamps attached, in which every cost of manufacture and distribution included was 2¼ cents per H. P. hour (3 cents per K. W. hour).

The Metropolitan Electric Railway of New York is reported to have contracted with the Third Avenue Railway for power at 1⅛ cents per El. H. P. hour (1½ cents per K. W. hour). It seems probable that this price is too low, but probably other considerations than its cost to the Metropolitan Co. fixed their prices of power. "New financiers" never object to robbing Peter to pay Paul.

Making a study of the Edison Station of Boston

C = \$6,260,137.57
N = 12,925 H. P.
F = \$288,258.79
x = 10%
y = 5%

$$\boxed{\frac{(x+y)\,C+F}{N} = \$94.95\tfrac{4}{10}\text{ pr. H.P. pr. yr.}}$$

Let $I = N$ H. P. to obtain average price.
" $n = 365 \times 4 \times N = 18{,}870{,}500$ H. P. hours approximately.
" $v = 2\frac{1}{4}$ cents.
$p = 6\frac{1}{2} + 2\frac{1}{4} = 8\frac{3}{4}$c. per H. P. hour.
or about 12c. per kilowatt hour as an *average*.

For another instance a large office building requiring 2,000 sixteen cp. lamps (133 H. P. max. demand) uses them 1 hour per day for 5 months in the year.

$2{,}000 \times 150 \times 50 = 15{,}000$ K. W. hours,
or $n = 20{,}000$ H. P. hours.
$I = 133$ H. P.
$p = 2\frac{1}{4} + 63 = 65$c. per H. P. hour,
or about 87c. per K. W. hour.

Another instance :

A 100 H. P. motor attached is to be operated 300 days, 10 hours to be full capacity for 1 year.

$I = 100.$

$n = 300 \times 10 \times 100 = 300{,}000$ H. P. hours.

$p = 2.25 + 3.16 = 5\frac{4}{10}$c. per H. P. hour.

Manifestly, the office building is not a possible consumer at lucrative rates, and the motor is a profitable consumer at much less than the average rate of 8¾c. H. P. hour.

Another instance :

An underground passage is to be lit for one year by 15 lamps which are never extinguished.

$I = 1$ H. P.

$n = 365 \times 24.$

$p = 2.25 \times 1.1 = 3.35$c. per H. P. hour.

say 4½c. per K. W. hour.

The annual charge of $94.95.4 per installed H. P. may not be acceptable to all managers. If they can attach twice as much H. P. to the conductors as they have installed in generators it can be divided by two, and used in equation 3.

Power for lighting not used, between 5 P. M. and 8 A. M., should be the subject of special contracts, and discounts.

It will be necessary to refer to the report of the Gas and Electric Light Commissioners of Massachusetts for 1901 to obtain the complete details of the operation of the various gas and electric companies.

This report omits the total annual output of the electric light companies but gives the annual output of all of the gas companies.

The only means we have afforded us of estimating the annual output of the electric companies is the statement of tons of fuel annually burned.

In many cases this is not given where water power is used or current or steam are purchased.

Whenever the coal burnt is given, the prices have been computed on the assumption that each ton of coal is equivalent to 400 electrical horse-power hours. This is about the same as 5 lbs. of coal or 50 lbs. of steam per electrical horse-power hour, made and sold.

This may be an over-estimate even in excess of greatest economy of station operations and if any instance occurs in which more or less than 400 horse-power hours in electricity are developed to the ton of coal the prices obtained in the tabulation should be multiplied by 400 and divided by the actual output in horse-power hours per ton of coal consumed.

The same result can be obtained in kilowatt hours by multiplying the prices obtained by 300 and dividing by the number of kilowatt hours actually obtained per ton of coal consumed.

The tabulation of the first eleven companies is for those serving communities of less than 5,000 population and in that case the prices have been computed for both 400 horse-power hours and 200 horse-power hours per ton of coal burnt.

Probably 200 horse-power hours is nearer the actual fact in these cases. The writer regrets that he has been unable to obtain the actual output of the various companies reported.

In every instance in the tables, the assumption has been made that the number of horse-power attached to the distributing system is equal to that installed in the station and the result obtained is the average price which should be received under this assumption. The formula given for the selling price (p) must be used in each case with the actually existing value of (N) installed horse-power and (I) attached horse-power when the assumed condition of equality does not exist.

If the total attached H. P. is used in the place of N the total installed H. P. and each consumer is reckoned at his individual attached H. P. (I) it is possible with a closely approximate estimate of his annual horse-power hours (n) to determine the price which he should pay in order to yield a profit to the electric company.

Manifestly the larger the total attached H. P. and the larger the total H. P. hours annually the lower the profitable average price (p) can be put.

In cases where the coal burnt is not given it has been necessary to estimate very roughly the anuual horse-power hours from the record of the commercial and public lights attached. Incandescent 16 candle-power lights being reckoned at 50 watts, 2,000 candle-power arc lights at 750 watts and 1,200 candle-power arc lights at 375 watts, all of which are rough approximations only.

In every case *uncertainty can be eliminated by the use of the actual horse-power hours developed* per ton of fuel as measured on the station meters *if they are correct.*

RESUMÉ.

Prices must be fixed so as to produce a profit on the investment per annual unit produced.

Until electricity can be economically stored no uniform average price to all consumers will be judicially fair.

Consumers using electric light or power for long hours are entitled to very low rates by meter.

And those using them occasionally or for short hours must pay high rates.

Gas should be used for lighting under 3 hours per day.

Massachusetts Electric Light Companies Serving a Population of less than 5,000.

Name of Company Population served	Cash Capital Invested C	Electrical Horse Power installed N from dynamos	Fixed Expenses F	Operating and Distributing Expense.	Tons of Coal annually burned	Estimated annual H. P. hrs. 400 H. P. hrs. per ton of coal.	Estimated mfg. cost V per H. P. hour	For 400 H. P hrs. per ton coal. Average selling price H. P. hr. $p = \frac{(x+y)\,C+F}{N}\ \frac{I}{n} + v$ required by 15% on investment.	For 200 H. P. hrs. per ton of fuel.
Blue Hill El. L. Co. Canton, 4,584	$89,435.67	240	$1,449.28	$7,345.69	855	(400) 342,000 (200) 171,000	2.15c. 4.30	p = 8.16 + 2 15 = 10 31c . . . or 13 72 per K. W. hour . . Actual average received, 3 3 per H. P. hour.	20.62c. 27.44 6.6
Bridgewater El. Co. Bridgewater, 4,736	33,247.35	46	631.86	4,907.45	417	(400) 166,800 (200) 83,400	2.94 5.88	p = 3.37 + 2 94 = 6.31c. . . . or 8.41 per K. W. hour . . . Actual average received 4c. per H. P. hour	12.62 16.82 8.
Franklin El. L. Co. Turner Falls, 4,202	13,137.43	55	325.83	2,995.12	Two water wheels 50-h. p. each.	30 arcs . . . 120,000 600 ten c. . . 36,500 Total. . . . 156,500	1.91	p = 1.47 + 1.91 = 3.38c. . . . . or 4.51 per K. W. hour . . . . . Actual average received 2.54c. per H. P. hour.	
Lee Elec. Co. . . . Lee, 3,596	64,584.32	230	1,000.97	5,026.51	591	(400) . . . 236 400 (200) 118,200	2.12	p = 4.52 + 2.12 = 6.64c. . . . . or 8.85c. per K. W. hour . . . . Actual average received 4.2c. per H. P. hour	13.28 17.70 8.4
Lenox Elec. L. Co. Lenox, 2,942	27,433.61	Power Bought	870.81	5,837.02	Power bought	Estimated . . 117,000 (?)	5.	p = 4.26 + 5 = 9.26c . . . . . or 12.33c. per K. W. hour . . . Actual average received 6 8c. per H. P. hour	
Medway E. L. & P. Co. . . . . Medway, 2,761	12,636.16	67	956.65	688.30	One water wheel 55-h. p.	54,750	1.26	p = 5.21 + 1.26 = 6.47c. . . . . or 8 63c. per K. W. hour . . . Actual average received 2.6c. per H. P. hour	
Millbury Elec. Co. Millbury, 4,460	46,521.14	120	1,114.11	4,403.64	553	(400) 221,200 (200) 110,600	1.99 3.98	p = 3 66 + 1.99 = 5.65c. . . . . or 7.53c. per K. W. hour . . . . Actual average received 3.37c. per H. P. hour	11.30 14.06 6.74
Nantucket El Co. . Nantucket, 3,006	30,614.14	112	1,491.26	4,625.44	493	(400) . . . 197.200 (200) 98,600	2.34 4.68	p = 3.03 + 2.34 = 5.37c. . . . . or 7.16c. per K. W. hour . . . . Actual average received 3.42c. per H. P. hour.	10.74 14.32 6.84
Rawson L. & P. Co. Leicester, 3,416	25,599.94	200 Power purchased	2,149.95	6,347.72	Also two 30-h.p. water wheels	Com. Lts. . . 75 737 K.W. hrs. Public " . 19,385 " 126.828 H. P. = 95 122 "	5.	p = 4.72 + 5. = 9.72c. . . . . . or 12.96c per K. W. hour . . . Actual average received 5.81c. per H. P. hour	
S. Hadley Falls El. L. Co. . . . . . . S. Hadley Falls and Chicopee, 4,526	10,597.34	94 Steam and water power bought	148.02	3,991.77	Power bought	Com Lts. . . 15,800 K.W. hrs Public " . . 42.000 " 58.000 77,000 H.P. hrs. approximately.	5.2	p = 2.25 + 5.2 = 7 45c. . . . . or 10c. per K.W. hour . . . . . Actual average received 5.68c. per H. P. hour	
Weston El L. Co. Weston, 1,834	36,764.28	166	1,428.95	5,334.61	Steam bought	Com Lts . . 127,750 K W. hrs. Public " . 35 250 " 163 000 216.000 H. P. hours.	2.47	p = 3.21 + 2.47 = 5 68c. . . . . or 7.57c. per K. W. hour . . . . Actual average received 4.70c. per H. P. hour	

MASSACHUSETTS ELECTRIC LIGHT AND POWER COMPANIES.

Serving a Population of Over 5,000.

NOTE —For the purpose of comparison the total installed horse power (N) is assumed equal to the total attached horse powers (I). 400 horse power hours is assumed for each ton of fuel burned. When the actual horse-power hours generated per ton of fuel is known multiply the tabulated prices (p) by 400 and divide by the actual H. P. hours per ton to get corrected prices.

(1) Name of Company. Pop. served	(2) Cash Capital Invested C Annual Income.	(3) Elect. H. P. installed N	(3) and $\frac{C}{N}$ from dynamos.	(4) Fixed Expenses F	(5) Operating and Distributing Expense.	(6) Tons of Fuel Annually Burned.	(7) Annual H. P. hours (estimated). 400 H. P. hours Per Ton of Coal. n	(8) Estimated mfg. and dist. cost per H. P. hr. v	(9) Correct Average selling price per H. P. hour. $p = \frac{(x+y)C + F}{N} \frac{I}{n} + v$ required by 15% on investment.
Abington & Rockland El. L. & P. Co. . . . 9,816	$106,520.71 Inc. 22,939.36	400	$266.30	$5,173 13	16,093.07	1,035	414,000	3.89c.	$p = 5.11 + 3.89 = 9c.$ or 12c. per K. W. hour. Actual average received, 5.54c. per H. P. hour.
Amesbury El. L. H. & P. Co. 9,473	108,923.15 Inc. 19,594.31	600	181.54	1,550.20	16,408.64	1,614	645,090	2.54c.	$p = 2.77 + 2.54 = 5.31c.$ or 7.18c. per. K. W. hour. Actual average received, 3.03c. per H. P. hour.
Andover El. Co. . . . 6,813	63,430.25 Inc. 14,196.59	280	226 54	2,267.44	8,233.68	551	220,400	3.73c.	$p = 5.35 + 3.73 = 9.08c.$ or 12.11c. per K. W. hour. Actual average received, 6.44c. per H. P. hour.
Blackstone El. L. Co. . 5,721	32,286.32 Inc. 8,305.80	205	157.50	594.45	6,123.04	634	253,600	2.41c.	$p = 2.14 + 2.41 = 4.55c.$ or 6.07c. per K. W. hour. Actual average received, 3.3c. per H. P. hour.

(1)	(2)	(3)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Cohasset El. Co. . . . Scituate, 5,229	53,819.36 Inc. 10 433.07	153	352 00	897.89	6,068.04	424	169,600	3.52c.	$p = 5.29 + 3.52 = 8.81c.$ or 11.75c. per K. W. hour. Actual average received, 6.15c. per H. P. hour.
Dedham El. Co. . . . . Westwood, 8,569	161,732.27 Inc. 22,424 72	423	382.00	3,281.86	11,293.95	1,125	450,000	2.51c.	$p = 6.12 + 2.51 = 8.63c.$ or 11.51c. per K. W. hour. Actual average received, 5c. per H. P. hour.
Grafton El. Co. . . . . Sutton, 8,188	18,921.45 Inc. 5,375.17	67		1,169.05	4,914.02	Current bought	Com 50,000 K.W. hrs. Pub. 25,000 " " 75 000 " " 100,000 H. P. hrs.	4.91c.	$p = 4.01 + 4.91 = 8.92c.$ or 11.89c. per K. W. hour. Actual average received, 5 37c. per H. P. hour.
Great Barrington El. Co. 5,854	39,943.08 Inc. 17,157.02	704 water	57 00	1,071.31	7,667.02	Water power	Pub 63,000 K.W hrs. Com. 115,000 " " 178,000 " " 237,000 H. P hrs.	3.23c.	$p = 3 + 3.23 = 6.23c.$ or 8.30c. per K. W. hour. Actual average received, 7.24c. per H. P. hour.
Greenfield El. L. & P. Co. 7,927	65,506.79 Inc. 26,681.89	408	136.00	2,873.95	12,299.89	1,280	512,000	2.40c	$p = 2.48 + 2.40 = 4.88c.$ or 6.51c. per K. W. hour. Actual average received, 4.62c. per H. P. hour.
Medfield El. L. & P. Co. 9,538	183,867.05 Inc. 22,187.51	706	260.00	2,119.42	15,671.06	1,784	713,600	2.19c	$p = 4.16 + 2.19 = 6.35c.$ or 8.47c. per K. W. hour. Actual average received, 3.11c. per H. P. hour.
Milton L. & P. Co. . . 6,578	123,021.04 Inc. 28,154.70	507	243.00	2,455.94	11,250.17	1,263	505,200	2.23c.	$p = 4.14 + 2.23 = 6.37c.$ or 8.49c. per K. W. hour. Actual average received, 5.57c. per H. P. hour.
Orange El. L. Co. . . . 5,520	98,830 00 Inc. 12,204.49	235	420.00	2,699.77	3,464 64	3 water wheels 408 H.P.			

(1)	(2)	(3)		(4)	(5)	(6)	(7)	(8)	(9)
Union El. Co. . . . . . Franklin, Norfolk 5,997	70,777.87 Inc 12,281.39	165	429.00	1,166.93	8,827 71	870	348,000	2.54c.	$p = 3.38 + 2.54 = 5.92$c. or 7.89c. per K. W. hour. Actual average received, 3.53c. per H. P. hour.
Ware El. Co. 8,263	40,199.23 Inc. 10,311.83	147	270.00	1,057.79	5,849.72	334	133,600	4.38c.	$p = 5.30 + 4.38 = 9.68$c. or 12.81c. per K. W. hour. Actual average received, 8 60c. per H. P. hour.
Whitman L. & P. Co. . 6,155	40 802.21 Inc. 12,333.01	160	255.00	2,966.03	6 972.43	576	230,400	3.03c.	$p = 3.94 + 3.03 = 6.97$c. or 9.29c. per K. W. hour. Actual average received, 5.35c. per H. P. hour.
Winchendon El. L. & P. Co. 5,001	38,892.31 Inc. 8,202 64	105	370.00	1,570.33	3,772.95	Water power			
Adams El. L. & P. Co. 11,134	49,916.87 Inc. 10,959.34	370	135.00	1,398.67	6,080.85	500	200,000	3.04c.	$p = 4.44 + 3.04 = 7.48$c. or 9.97c. per K. W. hour. Actual average received, 5.48c. per H. P. hour.
Attleboro Steam & El. Co. 11,335	119,222.33 Inc. 30,865 10	525	227.00	4 408.95	16 833 86	2,054	821,600	2.05c	$p = 2.71 + 2.05 = 4.76$c. or 6.35c. per K. W. hour. Actual average received, 3.75c. per H. P. hour.
Central Mass. El. Co. . Palmer-Monson, Warren, 15,620	352 213.55 Inc. 34,746.38	946	372.00	3,960 56	14,969.83	1,116	446,400	3.36c.	$p = 12.72 + 3.36 = 16.08$c. or 21.44c. per K. W. hour. Actual average received, 7.80c per H. P. hour.
Framingham El. Co. . Ashland, 12,827	202,077.27 Inc. 25,663.57	430	500.00	4,716.01	12,972.41	1,620	648,000	2.00c.	$p = 5.40 + 2.00 = 7.40$c. or 9.87c. per K. W. hour. Actual average received, 4.00c. per H. P. hour.
Gardner El. L. Co. . . 10,813	66 462.71 Inc. 21,772.70	400	166.00	2,393.10	13,798.20	1,022	408,800	3 37c.	$p = 3.02 + 3.37 = 6.39$c. or 8.52c. per K. W. hour. Actual average received, 5.32c. per H. P. hour.

(1)	(2)	(3)		(4)	(5)	(6)	(7)	(8)	(9)
Hyde Park El. L. Co. . 13,244	358 445.47 Inc. 87,778.92	2,650	135 00	9,977.57	53,491 73	6,839	2,735,600	1.95c.	$p = 2.33 + 1.95 = 4.28$c. or 5.71c. per K. W. hour. Actual average received, 3.21c. per H. P. hour.
Leominster El. L. & P. Co. 12 392	132,463.29 Inc. 31,897.49	413	321.00	4 427.21	16,183.67	1,692	676,800	2.40c.	$p = 3.59 + 2.40 = 5.99$c. or 8.00c. per K. W. hour. Actual average received, 4.71c. per H. P. hour.
Marlborough El. Co. . Southborough 15,530	179,707.73 Inc. 26 875 95	622	260.00	4,838.32	11 961.08	1,153	461,200	2.60c.	$p = 6.90 + 2.60 = 9.50$c. or 12.67c. per K. W. hour. Actual average received, 5.83c. per H. P. hour.
Milford El L. & P. Co Hopedale, 13,463	84,015.20 Inc. 21,200 49	846		3,570.08	11,487.01	Power bought			
Natick Gas & El. Co. . Wayland, Wellesley 16,863	198,328.14 Inc. 36,685.45	1,120	177.00	5,018.07	30,065.77	3 529	1,411,600	2.13c.	$p = 2.46 + 2.13 = 4.59$c. or 6.12c. per K. W. hour. Actual average received, 2.60c. per H. P. hour.
Northampton El. L. Co. 18,643	171,121.34 Inc. 40,082 18	620	244.00	4,530.40	16,708.00	1,804	722,000	2.31c.	$p = 4.18 + 2.31 = 6.49$c. or 8.65c. per K. W. hour. Actual average received, 5.55c. per H. P. hour.
Plymouth El. L. Co. . 11,547	170,192.15 Inc. 26,524.84	565	301.00	4,336.88	16,160.10	2,025	810,000	2.00c.	$p = 3.69 + 2.00 = 5.69$c. or 7.58c. per K. W. hour. Actual average received, 3.27c. per H. P. hour.
Uxbridge & Northbridge El. Co. . . . 10,635	153 046.40 Inc. 13,224.69	640	240.00	1,721.22	9,504.25	747	298,800	3.18c.	$p = 8.26 + 3.18 = 11.44$c. or 15.25c. per K. W. hour. Actual average received, 4.42c. per H. P. hour.
Weymouth Lt. & P. Co. 11,324	172,626 94 Inc. 31,024.67	Total 890 water 400	194 00	4,418.10	17,874.18	1,770			

(1)	(2)	(3)		(4)	(5)	(6)	(7)	(8)	(9)
Gloucester El. Co. . . Rockport, 30,317	199,604.28 Inc. 47,923.39	683	292.00	5.955.89	21,685.65	2,204	881,600	2.46c.	$p = 3.97 + 2.46 = 6.43$c. or 8.57c. per K W. hour. Actual average received, 5.43c. per H. P. hour.
Haverhill El. Co. . . . Groveland, 39 551	349,356 45 Inc. 73,863.97	2.648	132.00	11 635.86	34.591.22	3.728	1.491,200	2.32c.	$p = 4.29 + 2.32 = 6.61$c. or 8 81c per K. W. hour. Actual average received, 4.95c. per H. P. hour.
Pittsfield El. Co. . . . Dalton, 24,780 Steam heat sold.	246,897.43 Inc. 86,714.17	1.375	180.00	12,486.16	53 962.16	6,115	2,446,000	2.21c.	$p = 2\ 02 + 2\ 21 = 4.23$c. or 5 64c. per K. W. hour. Actual average received, 3.54c. per H. P. hour.
Quincy El. L. & P. Co. 23.899	185,159.35 Inc. 45,518.39	673	275.00	8 625.14	23,090 23	2,019	807,600	2 85c.	$p = 4.50 + 2.85 = 7\ 35$c. or 9.80c. per K. W hour. Actual average received, 5.63c. per H. P. hour.
Salem El L. Co. . . . Peabody, 35,956	293 426.83 Inc. 97.628 43	1.913	153.00	17,174.99	54.357.70	4,383	1,753,200	3.10c.	$p = 3.49 + 3.10 = 6.59$c. or 8.78c. per K. W. hour. Actual average received, 5.57c. per H. P. hour.
Woburn L. H. & P. Co. Winchester, Stoneham 27,699	397,141.54 Inc. 62,683.71	1.907	208.00	9,826.32	27,017.04	3,189	1,275,600	2.12c.	$p = 5.44 + 2.12 = 7.56$c. or 10.08c. per K. W hour. Actual average received, 4.91c. per H. P. hour.
Somerville El. L. Co. . Arlington, 70,246	372,030.98 Inc. 107,771.69	1,125	330 00	11,299.31	63,925.69	4,620	1,848,000	3.46c.	$p = 3.63 + 3.46 = 7.09$c. or 9.45c. per K W. hour. Actual average received, 5.81c. per H. P. hour.
United El. L. Co. . . . Springfield, 69,164	841,510.09 Inc. 231,151.99	Total 4.090 water 2,835	205.00	40.357.47	96 143.49	2.947			
Edison Co. . . . . . . Brockton, 40,063	398.514.39 Inc. 80,821.70	1,057	377.00	12,128.30	42,864.93	3,927	1,570,800	2.73c.	$p = 4.58 + 2.73 = 7.31$c. or 9.75c. per K W. hour. Actual average received, 5.21c. per H. P. hour.

(1)	(2)	(3)		(4)	(5)	(6)	(7)	(8)	(9)
Cambridge El. L. Co. . 91,886	506,902.51 Inc. 174,115.88	,2300	220.00	18.593 49	93 949.55	7,331	2,932,400	3.20c.	$p = 3.22 + 3.20 = 6.42$c. or 8.56c. per K. W. hour. Actual average received. 6.00c. per H. P. hour.
Fall River El. L. Co. . 104,863	405.360.88 Inc. 184,432.73	3,000	135.00	25,055.67	133 791.35	6,237	2.494,800	5.36c.	$p = 3.44 + 5.36 = 8.80$c. or 11.73c. per K. W. hour. Actual average received, 7.39c. per H. P. hour.
Malden El. Co. . . . . Melrose, Medford, Everett, 89,206	506,974.47 Inc. 143,213.69	1.400	362.00	24,523.77	87.394.73	6,177	2,470,800	3.53c.	$p = 4.07 + 3.53 = 7.60$c. or 10.13c. per K. W. hour. Actual average received, 5.80c. per H. P. hour.
Worcester El. L. Co. . 118,421	699,222.50 Inc. 230,796 59	3.400	206.00	27,085.12	101,151.08	5,356	2,142,400	4 72c.	$p = 6.16 + 4.72 = 10.88$c. or 14.51c. per K. W. hour. Actual average received, 10.77c. per H. P. hour.
Edison Co., Boston . . 212,231	6,260,137 57 Inc. 1,261,808.21	11,100	564.00	288 258 79	396,818.15	44,126	17,650,400	2.25c.	$p = 6.95 + 2.25 = 9.20$c. or 12.27c. per K. W. hour. Actual average received, 7.15c. per H. P. hour.
Boston El. L. Co. . . . 500,961	5,646,377.63 Inc. 977,414.46	13,762	410.00	194 897.46	307 149.25	27,000	10,800,000	2.84c.	$p = 9.65 + 2.84 = 12.49$c. or 16.65 per K. W. hour. Actual average received, 9.05c per H. P. hour.

NOTA BENE.—Whenever the attached load exceeds the installed horse-power the profitable rates p may be made less than those deduced from installed H. P. in the station. Whenever the attached load is less than the installed H. P. the rates must be greater than those deduced to obtain the proper profit.

With the exception of a few of the larger stations it is not probable that an economy of coal equalling or exceeding 400 electric H. P. hours has been reached for a ton of coal. The ratio between the computed price (p) and the actual price received is not affected by a change in the horse power hours per ton of coal.

The report of the General Manager of an electric plant in order to convey an intelligible and practical analysis of the Company's business should cover the following points :

GENERAL MANAGER'S REPORT.

POWERS OF COMPANY.

Chartered in . . . . . for the purpose of. . . . .
Franchises . . . .
Population served . . . .

CAPITAL AUTHORIZED.

Bonds. . . . .
Debentures . . . .
Preferred stock . . . .
Common stock . . . .

CAPITAL ISSUED.

Bonds. . . . .
Debentures . . . .
Preferred stock . . . .
Common stock . . . .

SYSTEM.

Dynamos . . . .
Conductors . . . .

POWER INSTALLED IN STATION.

Boilers . . . . H. P.
Engines . . . . "
Water power . . . . "
Dynamos . . . . "
. . . .

POWER ATTACHED TO CONDUCTORS.

Miles of . . . .
Arc lights . . . . H. P.
Incandescent lights . . . . "
Motors. . . . . "
Heaters, etc. "
Number of consumers . . . .

GENERAL BALANCE SHEET.

Real estate	Bonds . . . .
Steam plant	Debentures . . . . . .
Electric machinery. . .	Preferred stock . . . .
Electric lines	Common stock . . . .
Meters	Notes payable. . . . .
Arc lamps.	Accounts payable . . .
Patent rights	Deposits (customers')
Due for light and power .	Unpaid dividends . . .
Fuel	Unpaid interest . . . .
Incandescent lamps. . .	Reserve fund . . . . .
Materials misc.	Premium account . . .
Investments.	. . . .
Notes receivable	. . . .
Cash	. . . .
. . . .	. . . .
. . . .	Profit and loss. . . . .

MANUFACTURING SHEET.

Coal and fuel	Light sales . . . . . .
Expenses at station . .	Power sales . . . . . .
Expenses for distribution	. . . .
	. . . .
General management .	. . . .
Taxes, office exp., etc. .	. . . .
Profit and loss. . . .	. . . .

PROFIT AND LOSS.

Interest	Balance $^{o}/_{a}$ . . . . . .
Dividends.	" mfg. acct. . . .
Depreciation.	Rents. . . . .
. . . .	Jobbing . . . .
Balance $^{n}/_{a}$	. . . .

	Gross.	Per K. W. hr.
Tons of fuel annually burned (2,240 lbs.)		
Kilowatt hours annually generated and sold		
Cost of material and labor for generating and distributing current		
Cost of investments, interest and depreciation		
Cost of general management, taxes, office expenses, etc.		
Cost total		
Average price received		
Authorized price		

The report of the General Manager of a gas plant should cover the following points :

GENERAL MANAGER'S REPORT.

POWERS OF COMPANY.

Chartered in . . . . . for the purpose of . . . .
Franchises . . . .
Population served . . . .

CAPITAL AUTHORIZED.

Bonds . . . .
Debentures . . . .
Preferred stock . . . .
Common stock . . . .

CAPITAL ISSUED.

Bonds . . . .
Debentures . . . .
Preferred stock . . . .
Common stock . . . .

SYSTEM.

Retorts . . . .
Generators . . . .

CAPACITY INSTALLED IN STATION.

Retorts . . . .
Generators . . . .
Purifiers . . . .
Holders . . . .

CAPACITY ATTACHED TO PIPING.

Miles of main . . . .
Street lights. . . . .
House lights . . . .
Meters . . . .
Number of consumers for light . . . .
" " " " fuel . . . .

GENERAL BALANCE SHEET.

Real estate	Bonds . . . .
Mfg. apparatus	Debentures . . . . . .
Street mains.	Preferred stock . . . .
Meters	Common stock . . . .
Due for gas	Notes payable . . . . .
Gas coal on hand . . .	Accts. payable. . . . .
Coke " " . . .	Deposits (customers') .
Tar " " . . .	Unpaid dividends . . .
Enrichers on hand . . .	Reserve fund . . . . .
Oil " " . . .	Premium acct. . . . .
Mdse. " " . . .	. . . .
Stoves and fixtures on hand	. . . .
. . . .	. . . .
. . . .	. . . .
Cash	Profit and loss. . . . .

MANUFACTURING SHEET.

Coal	Gas sales . . . .
Oil	Coke sales . . . . . .
Expenses at works. . .	Tar sales . . . .
Distributing expenses .	Amm. sales . . . . . .
. . . .	. . . .
General management. .	. . . .
Taxes, office exp., etc. .	. . . .
Profit and loss.	. . . .

PROFIT AND LOSS.

Interest paid.	Balance °/a . . . .
Dividends paid	" mfg. acct. . . .
Depreciation.	Interest . . . .
Sundry items	Premium . . . .
. . . .	Jobbing. . . . .
. . . .	Rents. . . . .
Balance n/a	. . . .

Tons of coal annually carbonized (2,240 lbs.) . . . .
Gals. of oil consumed . . . .
Thousands of cubic ft., annual production sold . . . . .

	Gross.	Per M.
Cost of material and labor for making and distributing gas.		. . .
Cost of investments, interest and depreciation.		. . .
Cost of general management, taxes, insurance, office expenses, etc.		. . .
Cost total		. . .

Average price received . . . .
Authorized price . . . .

CHAPTER VI.

Prices of Gas in Massachusetts.

THE data for this paper is taken from the annual report of the gas commissioners of Massachusetts for 1901. Such companies as have manufactured coal-gas or carbureted water-gas are the only ones that have been taken into consideration. Many of these companies have bought their gas from other companies, and consequently the data derived is not useful to the constructing engineer and is not used. Other companies have sold gas for municipal illumination and estimated the amount burnt. These companies, too, have not been used for the purpose of computing the cost and price of gas. Only such companies have been taken into account as have manufactured and metered their gas to consumers, and whose sales without meter do not appear to exceed 1 per cent. or 2 per cent. of the total sales by meter. This latter variation will not cause sufficient error to materially affect average results. The existence of electric light companies does not reduce the demand for gas.

KNOWLEDGE REQUIRED.

Whenever the erection of a new gas-works is contemplated or perhaps the purchase and reorgani-

zation of an old gas-works, the following questions require a definite answer: (1) What will be the annual gas sales? (2) What price shall be fixed per 1,000 for gas? (3) What will be a prudent investment of capital for the community in which it is proposed to furnish gas?

In the reply to all these questions we must be guided by the result of actual practical gas making and selling so far as we can obtain it.

CHARACTER OF CITIES.

From a careful study of the various cities of Massachusetts it would appear that, after they reach a population of 75,000 or thereabouts, the amount of gas used per capita is influenced largely by the increase of population; the total output increasing in a geometrical rather than an arithmetical ratio.

If the buildings of a city are concentrated, and high buildings of many stories erected, the amount of gas consumed per capita increases very rapidly, as for instance in the city proper of Boston. In cities of all sizes, any preponderance which manufacturing has obtained largely increases the sales per capita. For instance, we have in North Attleboro, Fitchburg, Attleboro and Fall River good instances of manufacturing cities of various populations ranging from 10,000 to over 100,000. We have in Cottage City a single instance of a town of 1,100 population for nine months in the year, and then during the summer season of 12,000 to 15,000 population.

MINIMUM PRICE OF GAS.

As the population of towns increases the price of gas appears to approximate more and more closely to $1 per 1,000, and the cash surplus, over cost of manufacturing and distributing and fixed expenses, appears to be somewhere between 25 cents and 30 cents per 1,000. At $1 for gas the price appears to have reached a practical minimum and the profit becomes dependent upon the reduction in the investment per annual 1,000 produced.

It should be remembered in a general way that $1 in the price of each long ton of gas coal means about 10 cents per 1,000 in the cost of gas, and that 1 cent per gallon in the price of oil used in carbureted water-gas means about 5 cents per 1,000 in the cost of gas. These latter three factors, then, should control any attempt to go below the price of $1 per 1,000 for gas.

Reference to the table of the gas companies of Massachusetts, arranged in the order of the price of gas, will convey detailed practical information as to results attained. It must not be assumed that in every instance reduction in price will assure increased consumption per capita, as might at first appear to be the case.

TABULATION.

In the tabulation subjoined the principal factors exhibited are: Consumption per capita, investment per annual 1,000, and the three factors of cost: *First,* manufacturing and distributing cost per 1,000; *second,* fixed expenses per 1,000, and *third,* depre-

ciation and profit per 1,000 for each of the companies.

In order to compare the population of cities with the consumption per capita, Fig. I has been laid down, and the various cities marked in the position resulting from their population and consumption per capita. It will be observed that, up to about 75,000 inhabitants, the consumption per capita seems to arrange itself rather according to the price at which gas is sold than according to the population. For an annual consumption of less than 1,000 cubic feet per capita the companies appear to charge from $1.46 to $2.23. For an annual consumption per capita ranging between 1,000 and 2,000 cubic feet the price averages from $1.01 to $1.91. Omitting Cottage City, for an annual consumption per capita ranging between 2,000 and 3,000 cubic feet, the price appears to average between $1 and $1.26. For an annual consumption exceeding 3,000 cubic feet per capita the price may be set at $1, and this consumption will increase in direct proportion to the population, reaching its maximum at 6,729 for Boston City proper.

From my investigations it would appear as though the annual consumption per capita is largely (although not entirely) independent of the population and its characteristics and rather a function of the price per 1,000.

In Fig. II the cities of Massachusetts are plotted with the price on the horizontal axis and the consumption per capita on the vertical axis. From the

nearly similar prices of various cities an average (see small circles) has been deduced as shown, and a broken line reaching from small circle to small circle drawn through them.

For the price of $1, which is the average of South Boston and Haverhill (both cities being under 75,000 inhabitants), we find an annual consumption per capita of 2,393, and these averages appear successively with the increase of price to be as follows:

Average annual consumption per capita.	Price per 1,000.
2,c66	$1.10
1,501	1.24
1,139	1.40
1,277	1.48
860	1.56
814	1.72
773	1.80
697	1.88
488	1.96
531	2.04
390	2.20
302	2.28

Through these points it would be impossible to draw any definite curve. But, an equilateral hyperbola appears, with rude approximation, to follow their general trend, and has been drawn in heavy lines. The equation of this equilateral hyperbola would appear to be:

$$p = \frac{361,800}{1,000\,\frac{N}{P} + 1,225},$$

in which p equals the price in cents, N equals the annual output in 1,000's, and P equals the population of the community. For instance,

$$\text{Let } 1{,}000\,\frac{N}{P} = 1{,}000 \text{ cubic feet. Then } p = \frac{361{,}800}{2{,}225} = \$1.63.$$

The following letters in answer to inquiries relating to various companies may be of interest in this connection :

REPORT ON A NEW GAS-WORKS FOR A SMALL CITY.

DEAR SIRS :—Referring to your verbal inquiry as to the correctness of the price fixed for gas at——I beg leave to submit the following considerations and results :

Although the directory population is claimed to be 22,500, so large a proportion of it is scattered negro population that I have deemed it better to assume the available and accessible patrons of the company at about 14,000. It is extremely difficult to predict the annual consumption per capita of any community ; the best result being only an average guess.

In order to make this guess practically correct, I have statistically classified all of the 60 or more gas companies in the State of Massachusetts, and graphically laid down the price of gas and the consumption per capita resulting from this price.

Notwithstanding the differences in management, which occur in various companies, I have found that the output per capita is dependent very closely upon the price per 1,000 cubic feet, until we reach a town of 75,000 inhabitants or over.

None of the gas-works of Massachusetts have fixed the price of gas below $1, and above a population of 75,000 it would appear as though the output per capita was directly proportional to the increase in population, the price being $1.

The manufacturing and distributing costs of gas throughout Massachusetts, in good works, ranges between 50 cents and 75 cents ; the latter price should be about the figure for towns under 75,000 inhabitants: and for this reason we will assume that such is the case in ———.

It is of interest to observe, in the following table, that the profit on gas at $1.75 would be somewhat greater than the 15 per cent. usually allowed to cover profit and depreciation on investment ; while at $1, assuming that the consumption would reach 2,350 cubic feet per capita (which for a residence town is hardly possible), the profit and depreciation would be less than 15 per cent. You will recall that the price was fixed at $1.50, to correspond with the price fixed at the ——— works.

Under the existing regimen, a year or more will elapse before the works will attain their proper output. After that, an annual net profit of 14 per cent., or about $6,300 can be expected ; and this will cover $125,000 investment at 5 per cent.

I am inclined to assume that $1.50 per 1,000 cubic feet will give the maximum profit at the consumption which the public will take at any price, because of the characteristics of the city.

Up to the present time you have invested at ——— $32,000, of which $8,000 remains unpaid ;

Towns supplied	Price gas per 1,000; actual	Population served	Gas consumed per capita. Cu ft	Investment, per annual 1,000	Cost of manufacture and distribution; per 1,000	Fixed expenses; per 1,000	15% depreciation and profit; per 1,000	Total charges = proper selling price; per 1,000	Cash surplus over selling price; per 1,000	Actual profit earned; 5% depreciation allowed. %	Dividend declared. %	Price coal per long ton	Price carbureting oil per gallon. Cents
Stoneham	$2.29	11 166	339	*	. .	. .	. .	. .	. .	. .	. .	. . . .	. .
Danvers	2 25	8 542	266	$12 16	$1 50	$.07	$1 82	$3.39	$0 68	0 6	0.0	B $5 25	. .
Southbridge	2.21	10.025	250	12 25	05	33	1 84	3 12	0.93	2.6	5 5	. . .	. .
Greenfield	2.16	7.927	531	12 79	1 01	54	1.92	3 46	0 61	0.0	6	B 5 20	. .
Marblehead	2.04	7 582	315	13 59	1 72	59	2 04	4.35	0 27 def.	—7	0.0	. . . .	. .
Nantucket	2.03	3.006	655	18 58	1 75	21	2.79	4.75	0 07	—5	0 0	B 5 00	. .
Ipswich	2 01	4.658	680	9 14	09	40	1.37	2.76	0 62	2	7	. . . .	. .
Adams	2.00	11,134	473	8 36	1 18	24	1.25	2.67	0.58	2	20	. . . .	. .
Athol	1 97	7.061	671	10 61	1 24	.32	1 59	3 15	0.41	—1	0.0	An 5 75	6
Quincy	1 94	23 899	. .	. .	. .	. .	. .	. .	. .	. .	. .	. . . .	. .
Easthampton	1.91	5 603	1,069	5 22	1 48	21	.78	2.47	0 22	—1	6	. . . .	. .
Plymouth	1 90	9 592	533	8.63	02	.44	1 29	2.65	0.54	1.3	10	. . . .	. .
Arlington	1 84	19.780	490	11 27	1 09	37	1 69	3.15	0 38	—1.6	0.0	. . . .	. .
Natick	1.77	9 488	630	10 74	1 12	.14	1 52	2.78	0 51	0 0	0.0	B 4 70	. .
Norwood	1 75	5 480	1,200	6 27	1 70	07	.94	2.71	0.02	—5	0 0	. .	. .
Webster	1.74	12,357	302	11 95	85	26	1.79	2.90	0.63	0.0	5	An. 6.50	4¼
Clinton	1 71	13.667	797	7 69	1 02	20	1 15	2.37	0.49	1.4	6	. . . .	. .
Marlboro	1.70	13.609	732	10 68	.75	.33	1.60	2 68	0.62	1	4	. . . .	. .
Spencer	1.70	7 627	700	27 34	1 03	14	4 10	5 27	0.53	—3	0 0	. . . .	. .
Milford	1 69	11.376	1,147	8 13	96	.17	1 23	2 36	0.56	2	0 0	. . . .	. .
Dedham	1.59	20,701	525	*	.	. .	. .	. .	. .	. .	. .	. . . .	. .
Pittsfield	1 58	21,766	9'5	6 28	66	35	.94	1.95	0.57	4	10	. . . .	. .
Beverly	1 54	13.884	1 060	6 90	61	32	1 03	1.96	0.61	4	10	. . . .	. .
Framingham	1 52	9.500	870	10 61	05	.27	2 94	4.16	0 30	—3 5	0 0	B 4 70	5⅞
Attleboro	1 52	11.355	1.765	5 02	75	.24	.75	1.74	0 53	5.5	12	. . . .	. .
Woburn	1 51	14.254	756	8 23	76	.37	1.24	2.37	0 38	—0.4	8	. . . .	. .
North Attleboro	1.51	9.973	1,714	3 66	.55	.28	.55	1.38	0.68	13 4	7	B 4.90	. .
Newburyport	1 49	14,478	1,150	. .	. .	. .	.	. .	. .	. .	. .	.	. .
Fitchburg	1.47	31,531	844	2 23	77	.23	.33	1.33	0.47	16	9	B 4 90	4½
Cottage City	1 46	1,100	2,447	. . .	. .	. .	. .	. .	. .	. .	. .	. . . .	. .
Amesbury	1 46	9.473	661	12 02	92	48	1 80	3 20	0 06	—5	0 0	. . . .	. .
Northampton	1 41	18 643	1 316	4 48	86	.23	.67	1.76	0.32	2	8	. . . .	. .
Brockton	1 41	40 063	1 121	9 64	.71	19	1 44	2 34	0 51	0.0	0 0	B 4 50	5
Chicopee	1 39	19 167	848	11 59	.71	44	1 74	2.89	0 24	—3	0 0	B 4 15	. .
Waltham	1 38	23 481	1.437	4 70	.73	.24	70	1.67	0.41	4	6	B 4.80	. .
East Boston	1 37	45 746	.	. .	. .	. .	. .	. .	. .	. .	. .	. . .	. .
Chelsea	1 36	34 072	1,079	8 52	*	. .	. .	. .	. .	. .	. .	.	. .
Salem	1 28	47.479	1.291	6 61	56	.26	.99	1.81	0 46	2	6	B 4 10	4½
Taunton	1 27	31,036	1.623	5 87	83	.20	.88	1.91	0 24	—1	9	. . . .	. .
Newton	1 26	50 109	. .	. . .	. .	. .	. .	. .	. .	. .	. .	. . . .	. .
Gloucester	1 21	26,121	. .	. .	. .	. .	. .	. .	. .	. .	. .	. . . .	. .
New Bedford	1 20	62 442	. .	. . .	. .	. .	. .	. .	. .	. .	. .	. . . .	. .
Fall River	1 13	104,863	1 811	3 97	51	.20	.59	1.30	0.42	5	8	. . . .	. .
Springfield	1.12	69,164	2 435	4 36	.55	.16	65	1 36	0 41	4	6 5	. . . .	. .
Charlestown	1 11	68 029	1 910	4 31	*	.	. .	. .	. .	. .	. .	. . . .	. .
North Adams	1 07	24 200	1 852	2 62	67	.15	39	1 21	0 25	5	8	. . . .	. .
Cambridge	1 01	91,886	3 317	3 85	51	.16	.58	1 25	0.25	4	10	. . . .	. .
Lawrence	1 01	81 127	1 804	5 50	57	.19	82	1 58	0.25	0.0	6	. . . .	. .
Haverhill	1 01	37 175	3 063	3 85	61	20	.58	1.39	0.20	0 0	0 0	. . . .	. .
Lowell	1 00	105 889	3 289	2 77	60	.14	41	1 15	0.26	4	12	. . . .	. .
Dorchester	1 00	84,061	2 048	4 45	*	. .	. .	. .	. .	. .	.	. . . .	. .
Lynn	1 00	78,145	2.523	3 06	61	08	.46	1 15	0 31	5	10	B 3 00	. .
Worcester	1 00	118 421	2,310	2 89	51	13	.43	1 07	0 36	7 5	18	. . .	. .
South Boston	.99	. . .	1 724	. . .	*	. .	. .	. .	. .	. .	. .	. . . .	. .
Boston City proper	.99	167,257	6 729	. . .	*	. .	. .	. .	. .	. .	. .	. . . . .	. .

* Gas bought.

and in order to complete the street mains and services, we should allow for an additional expenditure of $13,000, making a total of $45,000, as the cash cost of the ——— light and power station.

Price	$1.00	$1.25	$1.50	$1.75
Consumption per capita	2,350 cu. ft.,	1,650 cu. ft.,	1,150 cu. ft.,	800 cu. ft.
Annual sales of gas	$32,900,000	$22,500,000	$16,100 000	$11 200,000
Cash investment	45,000	45,000	45,000	45,000
Fixed expenses	3,500	3,500	3,500	3.500
Depreciation 5 per cent. of $45 000	2,250	2,250	2,250	2,250
Investment per annual 1,000	1.37	2 00	2.80	4.02
Profit and depreciation at 15 per cent.	0.21	0.30	0 42	0.60
Fixed expense per 1 000	0.11	0.16	0.22	0.31
Mfg. and dist. expenses per 1,000	0 75	0.75	0.75	0.75
	$1.07	$1.21	$1.39	$1.66

OPINION CONCERNING REORGANIZATION OF GAS AND ELECTRIC WORKS.

DEAR SIRS:—By reference to the tabulated results in the State of Massachusetts, we find that we can expect an average annual output per capita of 2,000 cubic feet with the price fixed at $1.10, and the population of ——— can be taken in round figures at 8,000.

Assuming the investment in the gas-works to be one-half of the total bonded indebtedness of the consolidated companies, we have $125,000 as its actual cash cost.

Price of gas per 1,000	$1.10
Consumption, per capita, cubic feet	2,000
Annual sale of gas, cubic feet	16,000,000
Cash investment	$125,000.00
Fixed expense	3,000.00
Depreciation, 5 per cent. of $125.000	6,250.00
Investment, per annual 1,000 cubic feet	7.81
Profit and depreciation, 15 per cent. of $7.81	1.17
Fixed expense per 1.000 cubic feet	0.19
Manufac. and distributing expense per 1,000	0.75
Total	$2.11

You will note from the above, that, in order to produce a profit and depreciation of 15 per cent., the price should be 2.11 per 1,000. The cash expended in fixed expenses, labor and material, is 94 cents, which with gas at $1.10, leaves a residue of 16 cents on each 1,000 cubic feet, or a total of $2,360 per year, after the present feeling of the community has subsided.

As the figures upon possible profit from gas are based on the actual practical results attained throughout the State of Massachusetts, there is no hope of exceeding them.

The projected sale of power to the electric railway should return $11,250 each year, of which we can reckon about $5,000 as cash residue. This will leave us the following figures:

Surplus from gas	$2,560
" " electric lighting	6,000
" " power	5,000
Total	$13,560

The addition of a district heating plant to the combined electric light and electric railway power station, would return a good profit, and still further improve the situation.

ESTIMATE OF SAFE INVESTMENT IN A SMALL CITY.

DEAR SIR:—You desire to know the amount which will be reasonably certain to return a profit, if invested in a coal-gas works in the city of ———, having a population of 7,600. The price of gas should be fixed at $1.50 per 1,000.

From the enclosed tabulated and graphical results, you can verify the following figures, or they

may suggest to you a modification in the price. The following data would appear probably correct:

Consumption, per capita, cubic feet	1,150
" total; 7,600 x 1,150 cubic feet	8,740,000
Probable fixed expenses, $3,500, or per 1,000 . . .	$0.40
" manuf. and dist. expense per 1,000	0.75
Total	$1.15
Profit and depreciation	0.35
Total	$1.50

Dividing 35 cents by 0.15, we obtain $2.33, as the profitable investment per annual 1,000 manufactured; and the total cost of the works should be limited to $20,393, covering a holder of 24,000 cubic feet capacity, and two benches of five retorts each, with all of the necessary appurtenances.

RESUME.

(1) The investment per annual 1,000 (M) produced is usually too large for profit in gas-works.

(2) In communities of less than 75,000 population the annual output per capita, is dependent upon the price alone with close approximation.

(3) The exception to this approximation occurs in manufacturing communities, where it is relatively greater.

(4) It is probable in rural residence communities that the price of gas will not bear out the rule (2) and that the output per capita will not increase in proper proportion to a reduction in price.

(5) In communities of over 75,000 population, with the price of gas at $1, the consumption per capita appears to increase with the population.

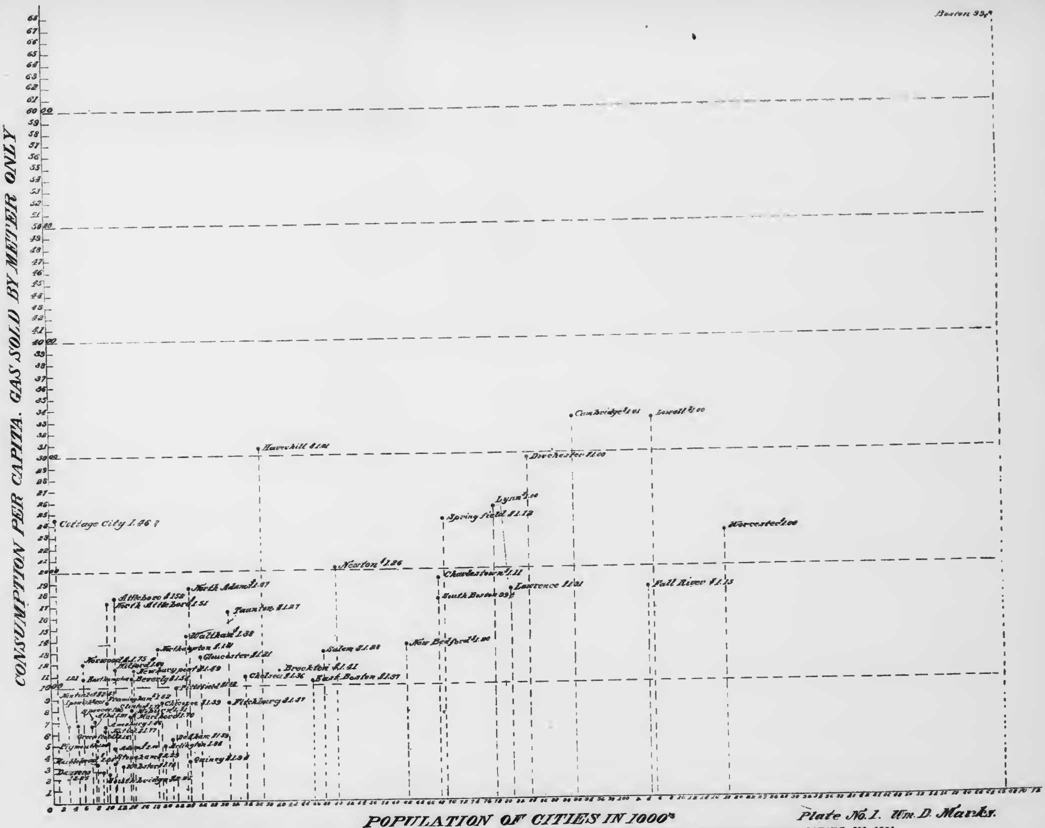

FIG. I. RELATION BETWEEN POPULATION AND PER CAPITA CONSUMPTION IN MASSACHUSETTS CITIES IN 1901.

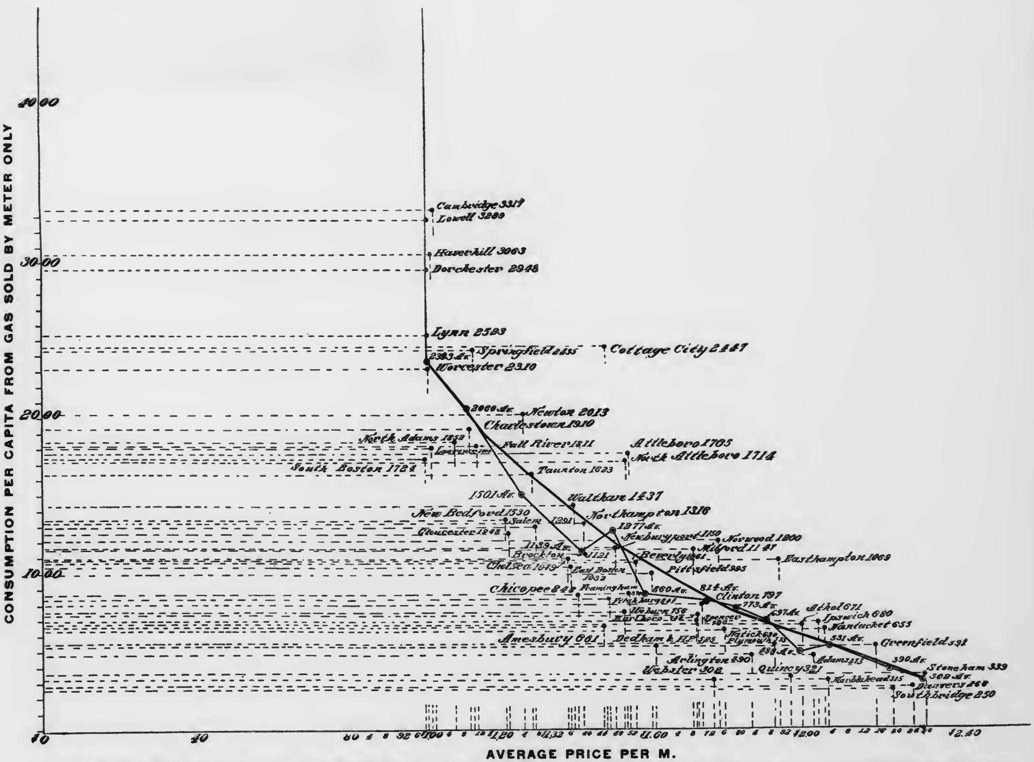

FIG. II. RELATION BETWEEN AVERAGE PRICE FOR GAS AND PER CAPITA CONSUMPTION FOR VARIOUS MASSACHUSETTS CITIES IN 1901.

CHAPTER VII.

Finances of District Heating from Electric Plants.

GENERAL CONSIDERATIONS.

MUCH disappointment to the stockholders of many Companies selling electricity for light and power has arisen because of the fact that, after a few years of apparent prosperity, dividends have ceased, and demands for extension, alterations and repairs, requiring further capital, have become imperative.

In other papers, the writer has shown very clearly, as he hopes, how entirely dependent the meter price fixed per kilowatt hour is upon the number of hours per day for which light or power is used.

He has also shown, since at present there does not exist any economical means of storing large quantities of electric power, that the investment made by the Company requires a constant charge per day to consumers of somewhere in the neighborhood of 1c. per 50 watt lamp, or 20c. per k. w. capacity of motor. (This would be about 15c. per h. p. of motor.) This constant charge, based upon the possible maximum requirements of a consumer, is due to the necessity of providing for the interest or profit and the depreciation upon the

investment required to meet the consumers maximum needs. If this constant charge, or some justly proportionate amount of it, is made to each consumer, as is shown in the paper entitled, "Methods of establishing prices for gas and electricity," then the question of any additional charge per k. w. hour, or per h. p. hour, becomes one of repaying to the manufacturers the actual cost per k. w. hour of producing electricity, in fuel and productive labor; and generally this cost may be said to range between 3c. and 7c. per k. w. hour, according to locality and management of works.

INCORRECT THEORIES.

One of the principal difficulties of Electric Companies arises from the efforts of managers to make electricity occupy a field for which it is not adapted.

Indeed, one large Metropolitan Company is today endeavoring to encourage short hour consumers, many of whom should be charged anywhere from 50c. to $1 per k. w. hour for what they use; and to make up its losses on these unprofitable customers, by charging a price that is judicially unfair to consumers burning two or three hours or more.

LONG HOURS LIGHTING FOR ELECTRICITY.

Would it not be better, by fixing the prices properly, to restrain the spread of electric lighting to the long hour field for which, in the absence of storage, it is particularly adapted, and to leave a field for short hour lighting open to gas, where it

can properly supersede the electric light, unless people are willing to pay more for the luxury of an electric light, which develops no products of combustion?

HEATING A SEPARATE PROPOSITION.

In a number of cases, the question of covering the constant expense (to which reference has been made) has been partially met by the attachment of a District Heating Plant to a non-condensing steam electric station. But even then the mistake that is frequently made by promoters of these heating plants, is to suggest to the bewildered manager that the income from the heating plant, being of a constant nature and usually at the rate of about one-third per cent. per cubic foot heated for eight (8) months of the year, will enable him to persist in his incorrect method of charging for electricity, and yet return a sufficient profit to the station to allow the resumption of dividends.

LIMITATION OF INVESTMENT.

In what follows, the writer has endeavored to show that there is a fixed limit as to the investment to be made in an attached Heating District Plant beyond which it will prove unprofitable, even though the steam which has hitherto been voided into the air as a waste product, might appear to cost nothing.

It is well for the advocates of any enterprise to remember that whatever its merits, it will not live if it does not first of all pay for its depreciation and a liberal profit.

STATISTICS.

A careful investigation, made in the minutest detail of the reports of the Electric Light and Trolley Companies now being operated in the densely populated States of Massachusetts and New York, reveals a uniformly strained financial situation that proves some similar underlying cause affecting them all.

DIVIDENDS.

From the exact records of the Public Commissions of Massachusetts, we find that out of sixty-three (63) operating Electric Light Companies, fourteen (14) only have been able to attain a dividend of 8 per cent., and that twenty-six (26) of these companies have not made any dividend at all.

Of the one hundred and nineteen (119) Massachusetts Electric Trolley Companies, only seven (7) have made a dividend of 8 per cent., and seventy-six (76) have made no dividend whatever.

These are accurate figures.

From less reliable data, in the State of New York it can be said that out of its one hundred and twelve (112) Trolley Companies, only nine (9) have declared any dividend whatever, and that of the somewhat greater number of Electric Light Companies three-fourths of them have made no dividend.

The New York State corporations may not have the close supervision given to Massachusetts coporations, and consequently it may be a fact that the issuance of bonds and stock in New York is not held so strictly within the limits of the actual cash investment, as is the case in the State of Massachusetts.

A somewhat extended experience in the West and South (where very little supervision is had over Electric Light and Trolley Companies) would go to show that, with a few exceptions, a still more unfortunate financial condition (for stockholders, at least) is in existence.

METROPOLITAN EXCEPTIONS.

A general exception to all of these statements can be made in the case of cities having 100,000 inhabitants or upwards.

This is not because there is any better, or, possibly, as good management displayed by the managers of metropolitan plants as is given in the smaller plants, but simply because the immense multitudes of users of Electric Light and Power, and the teeming mass of travelers packed into trolley cars, yields so large a profit that there is no trouble in paying the interest and principal of a bonded indebtedness surpassing the cash cost of the investment, and also generous dividends upon stock which represents no property at all.

DETAILED ANALYSIS.

A detailed and minute study of the operation of the various Electric Light plants, based upon their balance sheets (covering a year or more of operation in each case), reveals the following facts:

In most cases the price received for current per k. w. hour, or h. p. hour, is somewhat greater than the cost of the raw material and of the mechanical labor required for manufacturing

and distributing it; but it is rarely the case that the fixed annual expenses (such as taxes, insurance, salaries, office expense, etc.) are more than barely covered by the price charged for the current sold.

As far as the interest on the investment and the depreciation of the plant are concerned, it may be said that, with the exception of the metropolitan electric light and trolley companies cited before, where it is exceeded, it has in no case been covered in the returns obtained from the sale of current.

These statements in regard to Electric Light plants can be even more emphatically reiterated with regard to Electric Trolleys in both States.

In some few cases the interurban Trolleys (connecting towns of considerable magnitude) have proved profitable, largely by robbing of passengers the steam railways, which have heretofore served these towns.

It will be obvious that the reason that this can be done is that these trolley roads (running more frequently and sometimes almost at equal speed) have absorbed a business already built up by the steam railways for them.

In a very few instances indeed have urban Trolley Companies (confining themselves to towns of 50,000 inhabitants or under) succeeded in paying a dividend to their stockholders.

STANDARD EXCUSES.

The statement is frequently made that, as these enterprises are new, an initiatory period of unprofitableness must be expected; but this excuse

fails in the case of plants which have been in operation five or six years. And the second and later excuse is the rapid depreciation of the steam and electrical machinery, and of the poles and lines either under or over the ground. This latter excuse can usually be corroborated by a careful engineering inspection.

DIMINISHING HOPES.

In the meantime, stockholders are waiting for dividends to which they are entitled, and most of them are very much out of patience, for their chances of profit grow less each year while the plant wears out.

BY-PRODUCTS.

In seeking a remedy for this conditions of affairs, one naturally turns to the waste or by-products of these Stations, and the only waste products of an Electric Station are the exhaust steam and ashes.

UNSUCCESSFUL VENTURES.

Many attempts have been made to utilize steam for heating and power purposes.

The New York Steam Heating Company (after nearly twenty (20) years existence and the loss of much money) is paying an average dividend of 4 per cent. This is a direct steam heating company, not using the steam for any other purpose before applying it to heating.

The National Heating Company, of Boston, (based upon what appears to have been impossible conditions) also met with a complete failure in an

attempt to supply Heat and Power under great pressure and at high temperatures by means of hot water.

The fate of both these attempts at direct heating on a large scale have deterred many people from undertaking District Heating from Central Stations.

SUCCESSFUL VENTURES.

In the meantime, however, Low Pressure Steam Companies have put in one hundred and seventy-six (176) or more plants, a large percentage of which are furnishing steam heat and returning a profit on the investment. Their greatest success has been in the use of exhaust steam, at a pressure of from five to ten pounds per square inch, after being used at a higher pressure to generate electric current for Light and Trolley car purposes.

Hot water heating is now coming into considerable use, and there is a score of plants in the Western States which use their exhaust steam to heat water, and then pump this water through distances of a mile or more each way from the Station, and then heat houses with it.

These hot water heating plants appear to be giving unusual satisfaction to patrons, and in the few practical instances which I have been able to examine, undoubtedly save large sums of money for their stations which have heretofore not passed into the Treasury of the Company.

There appears to be no instance in which they do not at least return the cost of the fuel used in generating the electricity.

Practical experience only is convincing in avoiding possible superficial reasoning or incorrect theory.

The two following statements of the operations of a Heating and Lighting Company, using a Hot Water system, are given:

For the six months ending January 1st, 1900 (450 houses lighted and 199 houses heated), the account stands as follows:

Earnings:	
Receipts from heating, ...	$9,900.88
Receipts from lighting, ...	9,064.78
Expenses:	
Fuel, ...	$5,040.63
Wages and salary, ...	2,827.14
Expense (taxes, repairs, oil waste, etc.), ...	1,896.77
	$9,764.54

and for the year ending July 1st, 1901, their books show the following:

Earnings:	
Gross earnings from heating, . . .	$23,779.49
Gross earnings from lighting, . . .	21,696.86
	$45,476.35
Expenses:	
Fixed and office expenses, wages and repairs, ...	$11,300.00
Fuel, ...	15,500.00
	$26,800.00

As in both cases, the cost of fuel is largely exceeded, this Company is in a much more favor-

able position than companies deriving their power from a water fall, unless the water can afterwards be sold.

The proviso should be entered, however, that the depreciation of a heating plant, and the interest on the cost of the same, should prove less than the depreciation and the interest on the cost of a water power.

PRICES FOR HEATING.

In the case of this particular plant, the charge for seven or eight months heating to 70° Fahrenheit is one-third of a cent per cubic foot heated, and it has been found by practical experience that each residence averaging about 40,000 cubic feet of space and returning $132.00 has required the utilization of twenty-five (25) tons of slack coal, costing delivered between $1.50 and $2.00 per ton.

DISTANCE OF DELIVERY.

The greatest distance at which this hot water heat has been delivered from this station is three-fourths (¾) of a mile. The largest size pipe used being 6″ and the average 4″ for 200 houses.

The pumps force this hot water at an average pressure of 40 to 60 lbs. and at temperature ranging between 212 and 170°, each house requiring, on an average, two cubic feet of circulating water per minute. There is no limit as to distance of delivery save its cost in piping.

LOSS OF HEAT.

Under these conditions, it is stated that the average loss of heat in the ground is 15 to 20 per

cent. and that the exhaust steam of engine (lighting four houses or 160,000 cubic feet of space) will warm one house of 40,000 cubic feet.

RADIATING SURFACE.

The total radiating surface connected is stated to be 175,000 square feet, or about 22 square feet of radiating surface per thousand cubic feet heated by hot water.

COMPLAINTS AND OBJECTIONS.

There appears to be no complaint as to the heating of the houses served, and in the majority of instances the satisfaction expressed is complete.

In 1901 there were upwards of 176 steam heating plants in operation attached to central stations, and it is claimed that 80 per cent. of these plants had proved profitable and that the remaining 20 per cent. were failures financially only because of bad management.

In no case have users of station heat preferred to return to home firing. While satisfaction of parties receiving steam heating seems to be general, yet there were many minor individual complaints of water hammer noises and irregularities amongst these steam plants, which were not made in the case of hot water plants.

In the matter of hot water heating, the very large body of water and its low temperature makes it act somewhat slowly in heating up or cooling off a room.

STATION REGULATES HEAT.

The heat from hot water is less intense, and it has been found very possible to regulate the heat-

ing from a Station according to the temperature of the outside atmosphere, so that users are spared the annoyance of turning the heat off and on at the radiators.

In small plants (wherever the apparatus is properly installed) the hot water system has proved more convenient and uniform in action and about 20 per cent. cheaper in coal. A large body of water gives more stability and better regulation to the heating; and, for this reason, sudden and extravagant demands are not made upon it.

HIGH BUILDINGS.

In the case of very high buildings (since every two and three-tenths feet of height represents one pound of pressure) some inconvenience may arise from the high pressure required in a hot water system and a disconnected system (for transferring heat only) may have to be placed in the house to be heated, if the pressure in the street mains must be kept low. Direct steam heating may prove practically more feasible and profitable than hot water heating.

DEPRECIATION.

It has been found that the water of condensation from a steam heating plant acts upon the return pipe as an eager solvent, eating its way through steel in a very few years and through wrought iron in a somewhat longer period.

Very bitter discussions as to their relative merits have arisen between the advocates of steam heating and hot water heating.

RADIATING SURFACE.

In a large way, it would appear as though the average radiating surface used with steam heating is 15 square feet per thousand cubic feet of space heated, and with hot water it is about 21 square feet of radiating surface per thousand cubic feet.

The advantages to the consumer of obtaining heat from steam or hot water from a central station are obvious and need not be repeated here.

SUPPLY OF HEAT.

With Electric Trolley Railway systems, operating from 18 to 24 hours per day, the supply of steam is not as irregular as in the case of Electric Light plants where the maximum load occurs between 5 and 10 P. M. and the day load is apt to be very light.

On account of the large body of water which is contained in the mains and system of a hot water heating plant, it is obvious that this latter system is better adapted to Electric Light plants on the score of economy of heat because it can store heat.

The advocates of steam heating urge that the pumping system required by hot water is an additional expense. As, however, all of the steam used in pumping is also used in heating the circulating water, this is not a valid objection on the score of economy.

On the other hand, the back pressure (ranging from 5 to sometimes 15 pounds on a steam heating plant) will diminish the power of the engines used,

but as this back pressure reduces the cylinder condensation, it does not mean any serious loss in money to the users of the steam heating system.

STEAM CONDENSATION AND EXPANSION COSTLY.

In many of the larger stations established in late years, we find compound condensing engines of triple and quadruple expansion and the consumption of steam reduced to the neighborhood of 12 pounds per h. p. hour. If the stockholders wish their money used in a friendly rivalry for the purpose of reducing the consumption of coal, these attempts of engineers are laudable.

This form of economy enormously increases the cost of the steam engines while reducing the cost of fuel per h. p. hour we will say to 50 per cent. of that of good single cylinder condensing engines. There is a better method of saving money.

STEAM OR HOT WATER HEATING PROFITABLE.

Wherever exhaust steam heating or hot water heating is wisely used, however, it has been practically shown that the sale of the waste steam heat returns the price of fuel and a profit on the investment and also sometimes covers the cost of all labor in an Electric Station besides greatly reducing the cost of the engine plant.

SIMPLIFIES MACHINERY AND OFFICE WORK.

From a financial point of view, this result is preferable to the greatest economies of engineering skill in the expansion and condensation of steam

because the question always asked by the stockholder of his company is "What are the profits of the Company?"

In a paper called "Methods of Establishing Prices for Gas and Electricity" the writer has shown that to assure profits to Electric Lighting Companies it has been customary to make a sliding scale of prices per unit of measurement based on the hours of use of current for electricity ; but this arrangement, besides being elaborate, is a source of constant dispute and argument with consumers.

PRACTICAL EXAMPLES.

For the purpose of seeing what the effect of attaching a heating plant to an Electric Light Station is, we will take up a few instances.

The Edison Company of Boston is a metropolitan plant, and from its reports we draw the following data :

Gross earnings per installed h. p. one year		$113.68
Fixed expenses	$25.97	
Operating expenses	35.78	61.75
Accountants' profit		$51.93

From this Accountants' profit we should deduct a depreciation of 5 per cent. of $564, or $28.20, leaving a net profit of $23.73, or about 4 per cent. on the $564 cost per installed h. p.

Businesses of this type are entitled to at least 10 per cent. profit, or say $56.40 per installed h. p. (Presuming this to be the true cost.)

On looking at the fuel account, it would appear as though about 4 tons of coal were burnt annually per installed h. p.

Of this 4 tons, one ton would not be available for heating purposes between May 1st and October 1st, of each year.

It has been found by practical experiment that at the rate of one-third of a cent per cubic foot heated between October 1st and May 1st, each ton of coal burnt will heat 1,600 cubic feet of space to 70° fahr. and will return $5.30.

The Edison Company burnt 44,738 tons of coal in one year, of which 33,555 tons may be considered available for heating purposes. This will heat 53,668,000 cubic feet of space and will return a gross amount of $177,841,50.

If we regard this latter sum as being 15 per cent. of the capital which it is safe to invest in a district heating plant, we may appropriate $1,185,610 for this purpose.

Allowing 5 per cent. of this for depreciation on the investment, the heating plant will add $118,561 net profit to the income of the station, or a 10 per cent. dividend on the investment.

The Boston Edison Company declared an annual dividend of 11 per cent. on $4,310,500 capital stock and has set aside only $18,740 for depreciation on a plant which it claims has actually cost $6,260,137.

Perhaps it would be better to take up a smaller plant, and we will take at random the Amesbury Electric Company, which made a dividend of one

and one-quarter per cent. (1¼%) on $50,300 of capital stock. The investment per installed h. p. is $181.54.

From the report we have as follows:

Gross earnings per installed h. p. one year		$32.66
Fixed expenses	$ 2.58	
Operating expenses	27.39	29 97
Accountants' profit		$2.69

This Accountants' profit we should deduct from a depreciation of 5 per cent. of $181.54, or $9.08, showing a loss of $6.39, where a proper profit would have been $18.15 for each installed horse power.

During one year the Amesbury Electric Company burnt 1,714 tons of coal, of which 1,284 tons were available for heating purposes during eight (8) months. (Three-fourths (¾) of the coal in the case of lighting plants, two-thirds (⅔) in the case of trolleys should be assumed.) This would heat 2,054,400 cubic feet of space, and would return a gross earning of $6,805.20.

Assuming this to be 15 per cent. of a prudent investment to be made in a district heating plant, it would limit it to $45,368.

With the allowance of 5 per cent. for depreciation, the net profit to be added to the profit of the electric light plant would be $4,536.80, or 10 per cent. on the investment.

DIRECT DISTRICT HEATING.

In both of these cases we have limited the cost of a district heating plant to that which can

be served by the waste or exhaust steam from a non-condensing plant. Any extensions made beyond these limits at once become a direct steam or hot water heating enterprise and questions as to the profit derivable must be reckoned with on the basis of the cost of coal, labor and investment required to provide the heat and do *nothing* else. If this cost of coal, labor and investment approximate $5.30 per ton burned, it certainly will not pay at the rates suggested for heating.

In some instances it has been found profitable to use cheap coal (such as slack and buckwheat) to take care of a larger radiating surface than can be heated by the exhaust steam alone.

The estimate of the cost of a heating system must be kept within the limits prescribed and the amount of heating in cubic feet obtained in order to guarantee the success of a district heating plant. Both of these considerations require a careful study and canvassing of the heating district as a preliminary.

Whenever the climate permits, it can be unhesitatingly said that, with a properly designed and installed heating system attached to an electric station, the cost of fuel will be repaid to it and a fair dividend on the investment in the heating plant can be paid. There are conditions under which even more favorable results can be obtained.

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END OF TITLE